ANNUAL SCIENTIFIC REPORT

2002-2003

TEA RESEARCH ASSOCIATION
TOCKLAI EXPERIMENTAL STATION
JORHAT - 785008
ASSAM : INDIA

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CONTENTS

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CONTENTS

DIRECTOR'S REPORT

PRODUCTION

Water release characteristics of 30 TV clones were assessed. The ratio of relative water content (RWC) to leaf water potential (LWP) decreased with the progress of withering and the decrease rate was more in drought susceptible clones than the drought tolerant group. Leaf RWC was higher in drought tolerant clones compared to susceptible category of clones having similar LWP. These parameters are likely to help in selection of drought tolerant genotypes.

It was shown in one of the projects sponsored by the National Tea Research Foundation that the relative proportion of Gibberellin (GA_3) and Abscissic acid (ABA) controlled growth of the tea shoots. Quantitative studies of these two phytohormones revealed that the ratio of GA_3:ABA became as high as 3000: 1 during the active growing period while it was 1:1 in the mid winter dormancy.

Drought tolerant and susceptible clones were categorically subjected to the study of the rates of photosynthesis (Pn) transpiration (Tr) and stomatal conductance (Sc). The mean rate of Pn in drought tolerant and drought susceptible' clones were 8.59 and 8.80 μ mol/m^2/s, on the other hand the Tr rates were 3.33 and 3.53 μ mol/m^2/s. respectively. The mean Pn rates of 30 TV clones during the months of October, November, December and January were 9.46, 8.84, 8.82 and 7.51 μ mol/m^2/s while Tr rates were 4.54,3.84,2.98 and 1.80 μ mol/m^2/s. respectively

The collaborative project on SOP between TRA and SOPIB, USA was in progress for the fourth year. In the experiments conducted under this project effect of potassium sulphate (SOP) was being compared to that of MOP at the same level of application. Experiments were conducted on young tea, mature tea, high yielding, low yielding and standard TV clones at various locations. It was observed that in young tea and mature tea, application of potassium (110 kg/ha as SOP) resulted in 4% higher yield compared to the application of MOP at the same level during the 1st (LP) year and upto 10% more yield in the 2nd (DS) year. Higher numbers of primaries were found in the plots receiving potassium @ 110 kg and 165 kg in the form of SOP. Girh diameter (5 cm above collar) of the bushes was also higher under the above treatments. Effect of S with MOP would be evaluated in the next season.

An incubation experiment was carried out on nitrification inhibition in soil. Results indicated that urea blended with turmeric at 200: 1 ratio could inhibit nitrate formation upto 41% over a period of 30 days after which the inhibitory property of turmeric decreased and became negligible after 90 days. In another treatment, urea blended with dry mint powder at 20: 1 ratio could inhibit nitrate formation upto 54% over urea alone and the effect persisted upto 60 days after treatment. Fresh tea waste blended urea at 200: 1 or 100: 1 ratio could reduce nitrate formation in soil upto 33% over urea alone and the effect persisted upto 60 days after treatments. Thus, this laboratory study indicated that some naturally available materials like turmeric powder, dry mint powder, fresh tea waste, etc., could inhibit nitrification in tea soils. Field studies with these treatments would be taken up shortly. The programme has been considered now as of low priority.

The phosphate buffering capacity of soils belonging to 51 tea sections of 30 tea estates spread over South Bank area was determined. Results obtained from the P-desorption curves showed that the values

varied from 0.34 to 0.92 indicating that P-supplying capacity of these soils varied widely.Further, when the results were grouped into different yield categories, a positive relationship between phosphate buffering capacity and yield was observed.

Top soil samples collected from sections of different productivity levels in 30 tea estates were analysed for available phosphate. The data grouped in different yield classes showed that higher available phosphate (77-86 ppm) was associated with productivity level above 2500 KMTH. The effects of other associated factors are being studied.

A field experiment was in progress at the Tocklai Experimental garden on integrated nutrient management. The experimental plots (130 m^2) contained 117 bushes (clone CNM 340) planted in 1967 with 120 x 90 cm spacing and under shade (*Albizzia odoratissima*). Treatments involved use of inorganic, organic and biofertilizers at different proportions. Soil status in the whole profile upto 45 cm depth was assessed and yield records were being monitored. A pot culture experiment was in progress since July 2002 to study the effect of three biofertilizers on growth of tea plants (clone TV25). The biofertilizers were *Azotobacter* (BF-1), phosphate solubilizing bacteria (PSB) (BF-2), both obtained from Assam Agricultural University, Jorhat and a culture of diazotrophs (BF-3) isolated from tea soils at Tocklai. Preliminary results on growth parameters recorded two months after treatments showed that both BF-1 and BF-3 were effective in producing more branches and leaves as compared to YTD. Studies on the effect of various combinations of inorganic, organic and bacterial fertilizers on yield of tea are being carried out since 1999. The treatments were revised during 2002. Initial results showed maximum yield on application of inorganic manure (@ 150 kg N, 50 kg P_2O_5 and 150 kg K_2O/ha) along with additional dose of organic manure (@ 5 t/ha).

Aerobic composts and vermicompost were prepared using locally available material and worm *Eiseniafoetida*. The nutrient contents varied from 0.66-1.25% nitrogen, 0.5-0.8% phosphate and 0.25-0.30% potash. Work was also in progress to hasten the composting process with modifiers and to reduce the amount of dung required.

A field experiment was taken up at Lattakoojan T.E. of Golaghat district for improvement of compact soil under mature tea. Observations taken two years after imposition of treatments showed 15-27% improvement in the bulk density values, 10% in soil porosity and soil permeability by 10 times over control. The treatments also increased number of shoots and plucking point density. The programme is being discontinued now.

In a project sponsored by the Tea Board, 245 green tea shoot samples and 27 made tea samples were extracted for heavy metal analysis. Analytical work was carried out with the help of Atomic Absorption Spectrometer with 145 made tea samples for mercury, 99 made tea samples for lead, 18 made tea samples for cadmium and 115 made tea samples for copper. The results were submitted to the Tea Board. Thirty potted plants (TV 23) grown on soils treated with heavy metals were uprooted and separated into different components. Analysis of these samples for heavy metal contents is in progress.

Observations on growth and development of 27 years old TV -19 plants were studied in the original experiment with Systematic Fan Design. Closer spacing below 60 cm x 45 cm accommodating over 37,000 plants/ha resulted in more than 30% mortality. Plants spaced at 90 cm x 75 cm apart (14,800 plants/ha) produced the highest yield (2065 KMTH). In general, wider spacing resulted in the increase in all morphological characters studied including bush frame.

The study on flushing behaviour on 5 different clones such as TV1, TV11, TV20, TV22 and TV25 was carried out since 1999. Observations taken in pruned bushes showed that the numbers of branches at pruning level were more in TV22 followed by

TV11 and TV25, respectively. Bud-break also followed the same pattern, Fineness of leaf was found better in TV1 followed by TV22 and TV11. TV25 produced the highest yield although the treatment effects were not significant.

Field experiments on bringing up of young tea with different planting materials such as TV1, TV23, TV26, TV29 and TS 520 were being carried out at Tocklai. Different planting materials responded differently to the initial treatments as regards to their branching pattern. TV1, TV23 and TV29 plants showed better performance when these were lung pruned at 22 cm before decentering at 15-20 cm, while in TV26 plants uniform distribution of main branches was observed when the plants were decentered at 15-20 cm. In case of seed stock TS-520, although lung pruning at 22 cm exhibited beneficial results, distribution of branches were not uniform which needs further investigation.

Composition and valuation of different components of a standard tea shoot plucked at 7 days plucking round was studied in clonal tea TV-1. Initial results showed that 1st and 2nd leaf of a standard tea shoot constituted about 50-60% of its total weight. A growing bud constituted about 11 % of shoot weight and contributed about 22% of total valuation. The upper and lower stems also contributed 10% and 19%, respectively towards total weight and about 19% and 10%, respectively towards total valuation. The study was in progress.

Study on the effect of indigenous fungal inoculation for quick decomposition of pruning litter was under study since 2003 to investigate the extent of colonization of fungi and their succession under laboratory and field conditions. A few fungi were isolated from laboratory samples associated with decomposition of pruning litter *viz., Fusarium* spp., *Aspergillus* spp., *Penicillum* spp., *Pestalotia* spp., *Trichoderma* spp. and a few unidentified brown fungal forms.

The experiment to produce composite plants by grafting of internodal cuttings was started dur 1999 with limited success (survivality rate being o 3%). It was observed that most of he plants d primarily due to fungal contamination and lack proper humidity. In 2003, stocks TV9, TV18, TV and TV18 and scions TV1, TV21, S3A3 and T3 were selected for the purpose of grafting under id shade (polythene) and humidity.

Stocks were generally selected on the basis excellent rooting habit and adaptability to adve conditions whereas scions were selected on the ba of cup quality, pubescence and yielding potenti

An experiment was started in 1999 at Tocklai T to study the effectiveness of different methods soil rehabilitation. Planting was done in the area a rehabilitation under different methods in 20 Periodic data for soil nutrient analysis were tal which were analyzed by the Soil Department. Res obtained so far showed that K_2O content v maximum in the plots rehabilitated with Guatem grass while P_2O_5 content was highest in *Trichoder* + Cattle manure plots. N and organic carbon v found maximum under Mancozeb + sub-soil treatments. The experiment has since be considered as of low priority.

In another field experiment in South Bank, alternate method of soil rehabilitation involv thorough land preparation, organic mani incorporation and use of antagonistic fun preparation was being studied since 1998. Dur the period under report, analysis of soil samp drawn and field observations taken indicated t the soil structure remarkably improved from ini level of 74% soil aggregates. The soil bulk densi were also lower than the initial values. The gro of plants was satisfactory.

PLANT IMPROVEMENT

Based on satisfactory nursery performance of b the new clones P463 and P492 in tea estates different locations, plots with space planting w

raised along with best performing clones of the location for yield and quality assessment. Out of sixteen tea estates, so far six had planted these clones in the field. The remaining estates expect to plant them in the next season. The clones may be released after assessment of required physiological and biochemical parameters. Assessment for yield, quality and reaction to drought of clones 1.51 and 1.56 was completed and proposed to release as drought tolerant standard clones.

Application for registration of ten TV series clones (TV3, TV4, TV5, TV6, TV7, TV8, TV9, TV 10, TV11 and TV12) was made following the revised descriptor of NBPGR. Another set of 30 clones was made ready with completed characterization as per the revised descriptor to be submitted to the NBPGR for inclusion in the National Register.

Plants were raised in the Tocklai nursery from 223 germplasms collected from tea estates of N.E. India including Mizoram, Nagaland and Dehradun. One hundred and twenty eight were already planted in the field germplasm bank of New Botanical Area, Tocklai, and another lot of 75 germplasms was ready for planting.

To develop marker for quick selection of promising elite planting materials with very high quality potential, morpho-physiological and molecular characterization of selected germplasms were continued. Correlation studies would be performed on completion of the characterization.

Molecular characterization studies through PCR based RAPD analysis continued. Characterization of 11 tea germplasms was performed using 3 specific primers *viz.*, OPM-09, OPA-19 and OPM-18. The primer OPM-09 primed well compared to the other two. In another study, 7 Darjeeling clones and 5 wild tea germplasms were assayed using two random oligonucleotide primers *viz.*, OPM-09 and OPA-19. Results were being analysed by 'quantity one' software through gel documentation system.
The objective of this project is to characterize and improve tea through biotechnological tools. Tocklai is working on developing the hardening protocol for tissue culture derived tea germplasm and selection of water stress tolerant germplasm through physiological and biochemical studies. Micro-grafting technique under study was found to be encouraging for quick establishment in sleeves. Biochemical and physiological characterizations were focused on screening of drought tolerant clones. Quantitative estimations of AEA and proline were made in a few drought tolerant as well as susceptible clones. Molecular characterization (DNA-fingerprinting) was also performed in the same clones for identification of the genetic complements which are related to the important traits.

Selected triploid clones derived from diploid and tetraploid crossing were assessed for quality parameters. Organoleptic assessment of quality would be performed in the samples prepared through Environment Control Manufacturing (ECM). For triploid development artificial pollination was done with pollens of tetraploid to the female of high yielding diploid quality clones. Three parental combinations were crossed.

Three seed baries with new parental combinations (TV21 x TV 14, TV 13 x TV 1 7, TV 1 x TV2) were established. Assessment on yield and quality of 17 progenies under trial was in progress.

For the development of high yielding quality seed progenies artificial pollination was performed and 594 crossings done in 5 selected parental combinations of quality as well as standard clones. Assessment of progenies obtained from previous year's hybridization was in progress.

The selected seedling population of *Albizzia odoratissima*, based on faster and uniform growth of seedlings with shorter leafless period etc., was planted in the field. A programme was being worked out with an objective to develop a package of practice for raising ideal canopy and other features

of the shade trees.

A shade tree species *Anadenanthera peregrina* was growing luxuriantly in the Borbhetta Tea Estate of Tocklai, with a uniform spreading, single layered canopy and a very short leafless period. Techniques of *in vitro* as well as *in vivo* germination of the seeds were developed and seedlings raised in sleeves. Immature seeds were collected and grown in *in vitro* culture medium. Different parts of the seedlings were used as explant for culturing. Microshoots were developed from cotyledonary explant through embryogenesis.

Five selected tissue culture derived soma clones propagated for third generation were ready for plantation. Arrangements were being made to plant those under long term agricultural trial (LTT) along with other selected genotypes prepared for assessment. Potential soma clones would be released for commercial use.

Cuttings of another set of 42 soma clones propagated during the spring of 2001-02 were ready for plantation in plots to initiate studies on quality and yield potentials along with other traits.

Initial work for genetic transformation studies was started. A few *Agrobacterium* strains *viz.*, AGL-1, GV-3101 (both wild) and GV-2260 (with GUS Reporter gene) were collected and genetic transformation was attempted using the leaf disc from *in vitro* tea shoots. Success in this work would help in keeping the transformation protocol ready for immediate use

In continuation of the project work of NMITLI sponsored by CSIR on catechin biogenesis and development of flavour sponsored by National Tea Research Foundation studies were carried out. Tea shoots having uniform size of two leaves and a bud were collected from three extreme cultivars (i.e., extreme Assam, China and Cambod) and 59 different germplasms from different tea estates, considering the agroclimatic conditions and environmental factors and the chemo-profiles of individual catechins were estimated during the year. Individual components of catechins were identified and estimated by comparing with authentic standard compounds procured from Sigma Chemicals by using High Performance Liquid Chromatography (HPLC) with Phenomenax phenylhexyl column. It was observed that the extreme Assam cultivar contained more than 5% of total catechins as compared to China and Cambod varieties.

While comparing the catechin contents of the tea shoots in ten different clones collected from Upper Assam and Terai, it was found that catechin contents in the same clones from Upper Assam were 3-4% higher than that of Terai. From the effect of shade on the synthesis of total catechins and their individual components, it was observed that the catechin content was higher in unshaded condition than in shaded condition.

A study was carried out to have a better understanding about the effect *of* sunlight on phenylalanine ammonialyase (PAL), one of the key enzymes for catechin biosynthesis, it was found that PAL activity was higher in unshaded condition as compared to shaded condition.

As a part of the project, the black tea samples of three different cultivars were processed in different months (May to October) at Ging Tea Estate, Darjeeling. Terpenoid contents were found to be higher in the months of May and June as compared to other parts of the season.

PLANT PROTECTION

Eight new generation pesticide formulations, (i) Propergit 57 EC, (ii) Fenpropathrin 10 EC, (iii) Thiomethoxam 25 WP, (iv) Beta cyfluthrin 0.25 SC, (v) Diflubenzuron 25WP, (vi) Lambda cyhalothrin 2.5 EC, (vii) Alphamethrin 10 EC and (viii) Flowable sulphur 40% were considered during 2002-2003 for controlling different insect and mite pests of tea. Work was also completed for four other pesticides.

Four different combinations of new generation pesticides *viz.* (1) Lambda cyhalothrin 2.5 EC, Imidacloprid 17.8 EC, Ethofenprox 10 EC; (2) Beta cyfluthrin 0.25 SC, Oxydemeton methyl 25 EC, Cartap hydrchloride 50 SP, Ethofenprox 10 EC; (3) Cartap hydrochloride 50 SP, Beta cyfluthrin 0.25 SC, Thiomethoxam 25 WG, Imidacloprid 17.8 EC and (4) Oxydemeton methyl 25 EC, Beta cyfluthrin 0.25 SC, Cartap hydrochloride 50 SP, Thiomethoxam 25 WG were included in this study to determine the superiority of the sequence of pesticides in controlling *Helopeltis*. The study is in progress.

Trial for integrated management of livewood eating termite was continued in two tea estates namely, Durrung T.E. and Koloni T.E. at North Bank. The termiticides applied during December, 2002 Imidacloprid 17.8 EC (675 ml/ha) and Thiomethoxam 25 WG (500 ml/ha) were found effective to register 85% .and 89% control respectively after three months of application (March, 2003).

Experiments were laid out at Borbhetta T .E. to determine integrated effect of new acaricide molecules like Propargite 50 EC, Abametin 1.8 EC, Spiromesifen 240 SC, Diflubenzuron 25 WP and Flufenzin 200 SC, the findings of which are expected in the month of June-July, 2003.

Water and solvent extracts of five more herbs were selected for controlling foliar diseases of tea. These herbs were *Leucas linifolia, Adhatoda vasica, Clerodendron infortunatum, Solanum nigrum* and *Phyllanthus niruri*.

Work on fractionation of different active components from extracts of *Cassia tora, Acorus calamus* and *Lantana camera* was initiated.

Work was completed on one new formulation of copper oxychloride for controlling foliar diseases of tea. One microbial antibiotic and three new formulations of hexaconazole were being experimented under different field trials for controlling foliar diseases, namely, blister blight and black rot. Results completed so far showed the promising effect of the antibiotic formulation, particularly for controlling blister blight disease.

Infrastructure facilities were created for quality analysis of microbial biocide samples received from the member gardens of TRA. 9 commercial microbial biocide samples were analyzed for their quality assessment and *Trichoderma* species were isolated from 12 samples received from the member gardens.

Multi-residue analysis of tea and organic manure samples were carried out. A new method was developed for quality assessment of chemical pesticides received from the member gardens.

A new experiment on adsorption of pesticides by soil was initiated taking montmorrilonite clay as the adsorbing material for Chlorpyriphos to study the release pattern of the pesticide. Method development work for new generation pesticides was in progress.

Under a survey made for regional data generation, 38 black tea and 5 organic manure samples received from different member gardens were analyzed

PROCESSING

Tea shoots of three different popular Darjeeling cultivars were collected and manufactured in Ging Tea Estate, Darjeeling, twice in a month from May to October.

The aroma concentrates were prepared from 100 g black tea by steam distillation. Seasonal variations of 14 major volatile flavoury compounds in three different cultivars were studied. Terpenoid compounds specifically linalool, linalool oxides and geraniol were usually higher in the months of May and June than in July to September.
Lipid and fatty acid degrading volatiles were

generally higher in the months of July and August than in May, June, September and October.

Among the other components Benzyl alcohol was found to be higher in the months of July and August than the rest part of the season. However, b-ionone having fruity flavour was the highest in the month of May followed by June and lowest in the month of July. In addition to the projects, studies on enzyme activity were carried out with regard to isozyme separation using gel electrophoresis, measurement of glycosidase, polyphenol oxidase and peroxidase activities in different cultivars.

An Associate Developer was selected for further development and commercialization of the Modified Rolling Table for Daljeeling manufacture. The discharge mechanism of the roller was further modified by the Associate Developer in consultation with Tocklai. The Table would be tried commercially in the next season.

Five more units of Electronic Monitoring and Control System for Withering were installed in Azizbag, Bagrodia, Batelli, Joonktolee and Tengpani Tea Estates.

Under the Collaborative Projects with CMERI preliminary design of fluffing of leaves in withering and uniform feeding of Rotorvane were frozen and Associate Developers were being involved for further development and commercialization. The project on Sharpening of CTC Rollers in pairs was handed over to Vikram India.

The prototype machine based on micronizer concept for replacement of CTC machine was developed in collaboration with SEPTU (India) and shifted to TRA, Nagrakata, for trial. While the appearance of the finished product from the prototype was similar to that of CTC, the quality was yet to be ascertained. Also the consumption of power was found to be very much in the higher side. Possibilities of re-engineering the machine to minimize the shortcomings were being looked into.

The design detail of the building for the model tea factory at Tocklai under the Tea Automation Project was finalized, and tenders were invited from the already short listed pre-qualified contractors. In the meanwhile the machinery required for the proposed factory was finalized, suppliers identified and orders were placed. The Environment Controlled Manufacturing (ECM) Unit under the project had already been procured and installed temporarily at the Biochemistry Department, Tocklai.

VISITS

Mr. M. N. Gogoi, Acting Director; Dr. M. Hazarika, Deputy Director (Adm) & Head, Biochemistry Department and Dr. A. .K. Barooah, Head, Soil Department, attended the International Tea Convention in Kolkata held on 6-8 March, 2003 and presented a paper entitled "Global Perspective of Tea Quality".

Dr. S.C. Das, Second Biotechnologist, visited IHBT, Palampur during 24 February to 1 March, 2003 to discuss R&D matter related to DBTmulti-institutional collaboration project on "Improvement of Tea Through Biotechnological Tools" and CSIR-NMITLI project.

Dr. S. C. Das an Mr. K. K. Gohain, Soil Scientist, visited Mizoram in February 2003 to explore the feasibility of growing tea there and also to make a survey of wild tea plants growing in this state under the 9th Plan Programme.

Dr. B. K. Borthakur, Asstt. Mycologist, visited Calcutta University to present a paper in a National Symposium organised by Indian Mycological Society entitled "Current Trends in Research" on 23 February, 2003.

Dr. S. Sarma, Secretary, Dr. M. Hazarika, Dr. B. Bera, Asstt. Botanist and Dr. P. Tamuly, Asstt. Biochemist, visited NBRI, Lucknow, to participate in the Steering and Monitoring Committee meetings of the NMITLI Project at NBRI on 26 and 27 December, 2002.

Dr. T. S. Barman, Plant Physiologist and Dr. B. Bera, attended the Plantation Crop Symposium (PLACROSYM - XV) held at Mysore during 10-13 December, 2002. Dr. Barman presented a paper entitled "Role of auxin on growth of tea" and Dr. Bera presented a paper entitled "Randomly Amplified Polymorphic DNA (RAPD) markar analysis in tea (*Camellia sinensis* L.) generative clones."

Dr. A Buragohain, Head, Botany Department, presented a paper entitled "Phenotypic and genotypic evaluation of tea germplasm and their use in molecular breeding of tea (*Camellia* sinensis L.)" in the International Symposium on "Plant Biodiversity : Conservation and Evaluation" held at Bose Institute, Kolkata, during 17-20 December, 2002.

Dr. S. P. Baruah and Dr. K. Z. Ahmed, Scientific Assistants, Agronomy Department, and Dr. M. Goswami, Asstt. Advisory Officer, attended the 2nd International Congress on Plant physiology held in New Delhi during 8-12 January, 2003. Dr. Baruah presented a paper entitled "Effect of shade on the shoot growth pattern and its relation to yield." Dr. Ahmed presented a paper entitled "Study of the genetic variation on morphological and physiological characters of cultivated tea (*Camellia sinensis* (L) O. Kuntze) plant." Dr. Goswami presented a paper entitled "Study of the nature of bud break and shoot regeneration in cultivated varieties of tea (*Camellia sinensis* (L) O. Kuntze) under different tipping measures."

Er. P. K. Bordoloi, Water Technologist, Tocklai, attended a conference on 'Climate change - problems and issues' organized by Ministry of Environment and Forests at Administrative Staff College, Khanapara, Guwahati, on 11 September, 2002.

AREA SCIENTIFIC COMMITTEE SEMINARS/ MEETINGS

Area	Date	Attendance
ASC I and II	15.05.2002	81
ASC III	29.04.2002	62
ASC North Bank	25.04.2002	49
ASC Cachar	29.05.2002	150
ASC Dooars	23.05.2002	79
ASC Terai	22.05.2002	58

TRAINING AND LECTURE COURSES

Name of course	**Period**	**No. of participants**
5-Month General Training Course in Tea Culture	01.02.2002 – 28.06.2002	33
5-Month General Training Course in Tea Culture	01.08.2002 – 31.12.2002	26
6-Week V.P. Course	01.04.2002 – 10.05.2002	6
6-Week V.P. Course	03.10.2002 – 15.11.2002	9

TRA OFFICERS (as on 31st March 2003)

TRA OFFICERS

Located at Tocklai Experimental Station, Jorhat

DIRECTORATE

Mr. M. N. Gogoi	Acting Director & Head Tea Processing & Mfg. Adv. Dept.	B. Tech.
Dr. M. Hazarika	Deputy Director (Adm.) & Head, Biochemistry Department	M.Sc., Ph. D.

ADVISORY

Dr. S. K. De	Chief Advisory Officer	M.Sc. Ag., Ph.D.
Mr. R. L. Borkotoky	Advisory Officer	B.Sc.Ag.
Mr. P. K. Bordoloi	Water Technologist	B.E. Dip. H.P.D., M.S.
Dr. T. K. Basu	Advisory Officer	M.Sc.Ag., Ph.D.
Dr. M. Goswami	Asstt. Advisory Officer	M.Sc., Ph.D.
Dr. R. L. Hazarika	Asstt. Advisory Officer	M.Sc.Ag., Ph.D.
Dr. N. Ahmed	Asstt. Advisory Officer	M.Sc., Ph.D.

AGRONOMY

Dr. A. K. Dutta	Head, Agronomy Department	M.Sc., Ph.D.

SOIL

Dr. A. K. Barooah	Head, Soil Department	M.Sc.,Ag., Ph.D.
Mr. K. K. Gohain	Soil Scientist	M.Sc.
Dr. H. Goswami	Soil Scientist	M.Sc., Ph.D.

BOTANY

Dr. A. K. Buragohain	Head, Botany Department	M.Sc., Ph.D.
Dr. S. C. Das	Second Biotechnologist	M.Sc., Ph.D.
Dr. T. S. Barman	Plant Physiologist	M.Sc., Ph.D.
Dr. B. Bera	Botanist	M.Sc., Ph.D.

PLANT PROTECTION

Dr. Karan Singh	Head, Plant Protection Department	M.Sc., Ph.D.
Dr. B. K. Barthakur	Mycologist	M.Sc., Ph.D.
Dr. (Mrs) M. Borthakur	Entomologist	M.Sc., Ph.D.

BIOCHEMISTRY		
Dr. P. Tamuly	Biochemist	M.Sc., Ph.D.
Mr. M. R. Goswami	Asstt. Analytical Chemist	M.Sc.
TEA PROCESSING & MFG. ADV.		
Mr. S. Sanyal	Research Engineer	B.E.
Mr. R. C. Gogoi	Tea Taster	B.Sc.
STATISTICS & AGRI. ECONOMICS		
Dr. P. K. Karmoker	I/C, Stat. & Agri.Econ. Department	M.Sc., Ph.D.
Mr. R. Borpujari	Statistician	M.Sc., M.C.A.
Mr. P. K. Bordoloi	Statistician	M.Sc.
EXPERIMENTAL ESTATES		
Mr. R. Hussain	Estate Manager	B.Sc. Ag.
P. K. Dutta	Welfare Officer	B.Sc., LLB
ADMINISTRATION		
Mr. T. Khargharia	Addl. Administrative Officer	B.Sc.
Mr. S. Bhuyan	Asstt. Establishment Officer	M.A., M.P.M., DLL & L.W.
ACCOUNTS		
Mr. K. Bhattacharyya	Financial Controller	B.Com., A.C.A.
Mr. A. Chakraborty	Jr. Accounts Officer	B.A.
Mr. P. C. Neog	Jr. Accounts Officer	B.Com.
LIBRARY AND PUBLICATION		
Mr. S. Debnath	Incharge, Library & Publication	M.Sc.
MAINTENANCE		
Mr. S. Bora	Asstt. Technical Officer	B. Tech.
MEDICAL		
Dr. N. J. Bora	Medical Officer	MBBS, M.D. (A.M.)
Dr. B. K. Dutta	Medical Officer	MBBS
NAGRAKATA SUB STATION		
Dr. N. Borpujari	Chief Advisory Officer (WB)	M.Sc.Ag., Ph.D.
Dr. S. Baishya	Advisory Officer	M.Sc., Ph.D.
Dr. U. George	Microbiologist	B.Sc., Ph.D.
Dr. S. Sannigrahi	Asstt. Advisory Officer	M.Sc., M.Tech., Ph.D.

UPPER ASSAM ADVISORY CENTRE

Dr. P. Ghosh	Advisory Officer	M.Sc., Ph.D.
Dr. D. N. Saikia	Advisory Officer	M.Sc., Ph.D., PGDHRM
Dr. R. K. Baruah	Asstt. Advisory Officer	M.Sc., Ph.D.

NORTH BANK ADVISORY CENTRE

Dr. B. K. Laskar	Advisory Officer	M.Sc., Ph.D.
Mr. S. Varghese	Advisory Officer	M.Sc.Ag.

CACHAR ADVISORY CENTRE

Dr. B. K. Goswami	Advisory Officer	M.Sc.Ag, Ph.D.

TRIPURA ADVISORY CENTRE

Mr. P. Baruah	Advisory Officer	M.Sc.Ag., PGDHRM, DCO

DARJEELING ADVISORY CENTRE

Mr. S. K. Pathak	Advisory Officer	M.Sc.Ag.

TERAI ADVISORY CENTRE

Mr. S. K. Boruah	Advisory Officer	M.Sc.

SECRETARIAT

Dr. S. Sarma	Secretary	M.Sc., Ph.D.
Mr. D. Webber	Industrial Liaison Officer	B.A.
Mr. S. Dasgupta	Accounts & Audit Officer	M.Com.
Mrs. M. Nag	Executive Assistant to Secretary	M.A.

APPOINTMENT

Dr. A. K. Burahgohain joined TRA as Head, Botany department w.e.f. 4.7.2002.

RETIREMENT

Dr. M. P. Sinha, I/C, Advisory Department, retired on 30.6.2002

Mr. S. K. Chakravorty, Information Officer retired on 31.1.2003.

Mr. R. Phukan, Agronomist, retired on 28.2.2003.

LIBRARY AND PUBLICATION

LIBRARY STATISTICS

Books added to the Library	:	78
Journals (no. of issues) received on subscription	:	204
Journals (no. of issues) received free/on exchange	:	199
Annual Reports received	:	12
Publications issued to Departments	:	143
Publications consulted in the Library	:	822

LIBRARY SERVICES

The Library continued to extend its services to the scientists of Tocklai and outstations. Its services were utilized by V. P. Trainees, General Trainees and others from the tea industry. Students and teachers of the Assam Agricultural University, Universities of Dibrugarh, Gauhati and North Eastern Hill and Local Colleges utilized the Library facilities.

Scientists and research workers from Regional Research laboratory, Assam Agricultural University and other institutes within and outside the State consulted the Library. Some research workers from abroad also visited the Library and were benefited from its available facilities.

A DTP unit for production of Tocklai publications has been started at the Library.

Internet and email facilities started at Library, were used by scientists and other research workers at Tocklai

PUBLICATION RELEASED

Two and a Bud, Vol. 48, No. 1, 2001.

ADVISORY

MEMBERSHIP

The membership position during the year (2002-03) is shown in Table 2.01.

Table 2.01 TRA members in various regions

Region	No. of member estates
South Bank, Assam	181
Upper Assam	208
North Bank, Assam	108
Cachar & Tripura	106
Total	603

ADVISORY VISITS

The Advisory Officers continued to render useful services to member estates regularly. Extensive field visits were paid to provide routine and need based services in various aspects of field management.

A total of 741 visits were paid during the year. Regionwise break-up of visits is shown in Table 2.02

Table 2.02 Number of advisory visits during 2002-03

Region	Number of visits
South Bank, Assam	204
Upper Assam	263
North Bank, Assam	193
Cachar & Tripura	81
Total	741

WORKSHOPS

Seven workshops were organised during 2002-03. The workshops were well attended by the planters and different aspects of pruning and cold weather practices were discussed in details with practical demonstrations in the field (Table 2.03).

Table 2.03 Workshops

Area	Date	Venue	Topic	No. of participants
South Bank	05.12.02	Tocklai & Borbhetta	Pruning	97
Upper	19.11.02	Moran	-do	87
Assam	25.11.02	Tingrai	-do-	76
	26.11.02	Margherita	-do-	76
North	21.11.02	Bettybari	-do-	58
Bank	22.11.02	Sonabheel	-do-	24
Cachar	09.12.02	Narsingpore	-do-	100
Total				518

TRAINING COURSES FOR FIELD SUPERVISORY STAFF

Altogether 20 training-cum-demonstration programmes for field supervisory staff of different gardens on various aspects of field management were conducted in the member estates. Details of the same is presented in Table 2.04.

Table 2.04 Training cum Demonstration

Area	No. of programmes	No. of participants
South Bank	9	206
Upper Assam	3	206
North Bank	2	47
Cachar	1	14
Tripura	5	99
Total	20	572

TRIPURA ADVISORY BRANCH

This branch was opened on 17.06.2002 to cater to the needs of the small tea growers of the state. Seventeen Training cum demonstration programmes were organised during 2002-2003 with the help of the Dept. of Industry, Govt. of Tripura.

SOIL SAMPLE ANALYSIS

Soil samples from member estates were analysed regularly by the various soil testing units of the outstations and Tocklai for the purpose of deciding manuring policy and other related soil management practices. Regionwise break-up of the number of soil samples received and analysed is presented in Table 2.05.

Table 2.05 Analysis of soil samples

Region	No. of samples	No. of estimations
South Bank	2369	6128
Upper Assam	4891	14504
North Bank	4389	10850
Cachar	2105	5262
Total	13754	36744

DISTRIBUTION OF PLANTING MATERIALS

The number of cuttings and scions of released clones distributed by the different Advisory Branches are given in Table 2.06.

Table 2.06 Distribution of planting materials in different regions

Advisory Centre	No. of cuttings/ Scions	Seeds (unit)
Upper Assam	104140	7
North Bank	359980	2
Cachar & Tripura	66000	-
Total	530120	9

GREEN LEAF PRODUCTION

The Advisory Branches of North Bank and Cachar produced the following quantities of green leaf in their branch plots :

North Bank : 46,261 kg
Cachar : 16,678 kg

REVIEW OF FIELD PRACTICES

Land planning, drainage and irrigation

Appropriate land planning with an objective of sustainable development in all the cases of extension and replanting was emphasised. Land survey for laying out an effective drainage system as well as selection of planting materials and planting pattern continued to receive due attention. To invigorate physico-chemical and biological properties of uprooted soil recommended phyto-rehabilitation measures were adopted by most of the estates. Restricted outfall resulting from siltation/blockage of natural waterways remained major constraint in most estates of South Bank and this problem

appeared to be gradually worsening. Similar problem was also observed in some areas of North bank. In the year under review, stress was given on removal of congestions on disposal drains of some estates and the drainage of the estates concerned improved significantly. It is worth to note that the approach of catchment development at micro level to overcome drainage problems resulted in favourable conditions for plant growth. Pump drainage was considered only as a component of catchment development.

High water table mostly because of restricted outfall and also for frequent flood, drainage of flat areas continued to remain a problem. Other problems like seepage, flood etc. were also tackled at estate level to the extent possible.

Irrigation received due attention in the North Bank, in the drought prone areas of Golaghat, Nagaon and Cachar. Irrigation coverage was increasing throughout all the areas. Necessary guidelines were provided in planning, designing and laying out of irrigation systems to the member estates wherever required along with location specific design of tube wells and river erosion protection and gully plugging measures.

Vegetative propagation and planting materials

To enhance the rate of success in the clonal nursery, the important factors like use of standard cuttings, proper filling of the sleeves, setting of soils in sleeves of recommended size, regulation of watering in the nursery and timely raising of cuttings were highlighted by the Advisory Officers and most of the gardens followed the suggestions with success. In addition to virgin and forest areas, soil from paddy land, uprooted areas were also used after proper amelioration for sleeve filling. Synthetic shade materials (netlon) for overhead shade were widely used with fair degree of success.

All the recommended TV clones, a few garden clones like S_1A_3, Teen Ali 17/1/54 and biclonal seed stocks remained popular in all the regions. TV1, TV14, TV17, TV20, S_1A_3, P126, N436 were preferred for quality. However, seed stocks received less priority for planting in the plain areas of North Bank. Few gardens initiated to develop composite planting materials using locally adapted hardy vigorous clones as root stock and clones having quality parameters as scion.

Young tea management

The Tocklai released package and practices pertaining to young tea management were followed by almost all the member estates. Use of healthy planting materials, timely planting, application of appropriate pit mixture in proper pits, adequate tipping measures, green cropping, mulching etc. were emphasized during the advisory visits for reducing the payback period of young plantations. A bush population of 14,000-15,000 plants/ha using spacing like 105-110 cm x 65-75 cm (single hedge) or 105-110 cm x 70-75 cm x 65-75 cm (double hedge) remained popular.

Pruning cycle

To have a profitable blend of quality and quantity, 3-year pruning cycle of LP-UP-DS, LP-DS/MS-UP were widely practised by the member estates. In some areas of Assam, 4-year cycles (LP-UP-DS-UP/MS) were also used widely. In Cachar and Tripura pruning cycles like LP-UP-UP, LP-UP-DS/MS-UP were more popular but due to increasing market demand for quality some progressive tea estates started adopting pruning cycle of LP-UP-DS or LP-DS-UP in some of the sections.

Rejuvenation and infilling

This practice was continued in the most of the estates to improve productivity of certain potential matured teas. TV20, TV22, TV23, Tv25, TV26, TV27, TV28 and biclonal seed stocks of TS 462, TC463, TS 464 and TS 520 were preferred for infilling and inter planting.

Plucking

In order to maximise quality and quantity of harvest, the estates usually followed 7-8 days plucking round from the beginning till the initiation of autumn flush and thereafter plucking round got slightly extended to 8-9 days towards November-December. A leaf rise in October-November in certain tea sections to be left unpruned next season was emphasized and followed by some estates. Shear plucking was also done on a trial basis by some estates during peak flushing periods. A high labour output was reported from most of the estates. But problem like quality-deterioration continued to exist.

Pest and disease

Helopeltis remained as a dominant pest throughout the whole season in the estates of South Bank, Upper Assam and made its presence felt in North Bank. In general, red spider mite, thrips, greenfly, *Helopeltis* and looper caterpillar were common pests, while red rust was a common disease in most of the estates of Upper Assam, South Bank and Cachar. Green weevil was also reported at variable degrees in North Bank. In Cachar and North Bank termite continued to pose problem both in young and in mature tea. Blister blight and black rot were reported only in localised areas. Adoption of integrated pest/disease management practices by timely and judicious use of chemicals and cultural methods were emphasised during advisory visits. To minimise pesticide residue in made tea as well as to enhance the pesticide use efficiency, selection of approved pesticides and application of the same in recommended doses at appropriate stages of pest build-up were highlighted.

Weed control

Paraquat, 2,4-D and Glyphosate were the common herbicides used by the member estates. Oxyfluorfen, a pre-emergent herbicide for young tea also gained popularity in many estates. For controlling grassy and shallow rooted broad-leaf weeds use of Diuron + Paraquat mixtures became popular. *Polygonum chinensis* and ferns were found resistant to normal weedicides. Physical removal was found very satisfactory for controlling these weeds. A few estates also tried with Glyphosate and 2,4-D + Diuron mixture for controlling *Polygonum chinensis* and ferns with moderate success.

Strip weed control was practised in teelahs by some estates of Cachar as a measure against soil erosion.

Manuring

The member estates undertook fertilizer application based on potash and sulphur status of soil as well as productivity of tea sections. Nitrogen, phosphate, potash and sulphur doses varied between 90 and 165 kg N/ha, 20 and 50 kg P_2O_5/ha, 50 and 165 kg K_2O/ha and 20 kg S/ha respectively in the estates of Brahmaputra valley and Barak valley. Many tea estates were having the habit of not applying phosphate every year. But due to the emphasis given by the Advisory Officers for balanced manuring most of the tea estates started applying phosphate in every year irrespective of the style of pruning. Foliar application of Zinc and Urea at recommended doses continued to be practised in unprune sections.

Shade

Both permanent and temporary shade species were in new plantations as well as replanted areas. *Albizzia chinensis, Acacia lenticularis, Dalbergia silica, Dalbergia sissoo* were widely used as permanent shade and *Indigofera teysmanii, Leucaena leucocephala, Albizzia moluccana* were used as temporary shade trees, *Crotalaria anagyroides* was widely accepted for planting in between young tea rows. Judicious lopping of shade tree branches in the over shaded areas continued to be a practice to ensure proper penetration of sunlight.

GENERAL

Transfers

Dr. S.K. De took over the charge of Chief Advisory Officer, Tocklai.

Dr. B.K. Goswami, Advisory Officer, Tocklai transferred to Cachar Branch as Incharge.

SUMMARY OF EXPERIMENTAL RESULTS

NPK trial

Two multilocational trials at Hazelbank T.E. (AS 214) and Phulbari T.E. (AN 220) has been continued since 1990-91 to ascertain the regional response of tea to NPK fertilizers in various combinations. The yield data for the year 2002 are presented in Table 2.07.

In general, production of clone S A in unpruned year increased in accordance with increasing dose of Nitrogen under Upper Assam condition and dose of 200 kg N/ha produced significantly higher yield compared to 100 and 150 kg N/ha. In deep skiffed teas of TV1 a dose of 150 kg N/ha recorded significantly higher yield than rest of the doses except 250 kg N/ha under North Bank condition.

Table **2.07** Yield response to various levels of Nitrogen during 2002

Levels of N (kg/ha)	Yield in KMTH	
	AS 214 (UP) S A	AN 220 (DS) TV1
100	3434	3388
150	3449	3548
200	3664	3222
250	3709	3493
CD (P=0.05)	154	161
CV%	5.03	5.49

(Each figure is an average of 12 combinations of P_2O_5 and K_2O : 3 level of P_2O_5 - 20, 50 and 80 kg/ha and 4 levels of K_2O - 75, 125, 175 and 225 kg/ha)

Yield of unpruned tea of clone S3A3 and deep skiffed tea of clone TV1 remained unaffected due to different levels of P_2O_5 under both Upper Assam and North Bank conditions.

Table 2.08 Yield response to different levels of P_2O_5 during 2002

Levels of P_2O_5 (kg/ha)	Yield in KMTH	
	AS 214 (UP) S A	AN 220 (DS) TV1
20	3598	3362
50	3516	3393
80	3577	3484
CD (P=0.05)	NS	NS
CV%	5.03	5.49

(Each figure is an average of 16 combinations of N and K_2O : 4 levels of N 100, 150, 200 and 250 kg/ha and 4 levels of K_2O 75, 125, 175 and 225 kg/ha)

Table 2.09 Yield response to different levels of K_2O during 2002

Levels of K_2O (kg/ha)	Yield in KMTH	
	AS 214 (UP) S A	AN 220 (DS) TV1
20	3598	3362
75	3561	3531
125	3528	3354
175	3673	3481
225	3494	3287
CD (P=0.05)	NS	161
CV%	5.03	5.49

(Each figure is an average of 12 combinations of N and P : 4 levels of N - 100, 150, 200 and 250 kg/ha and 3 levels of P_2O_5 - 20, 50 and 80 kg/ha)

In this study no significant difference in yield of clone S A was observed at different levels of potash application under Upper Assam condition, whereas

in North Bank condition a dose of 75 kg K_2O/ha produced significantly higher yield than 125 kg/ha and 225 kg/ha in the deep skiffed year in case of clone TV1 (Table 2.09).

Table 2.10 Effect of N, P and K alone over no manuring during 2002

Treatments	Yield in KMTH	
N - P_2O5 - K_2O Kg/ha	AS214B (UP) S3A3	AN220B (DS) TV1
T1 : 0-0-0 (control)	3172	2951
T2 : 150-0-0	3400	3341
T3 : 0-50-0	3078	2931
T4 : 0-0-125	2791	3115
CD (P=0.05)	NS	NS
CV%	7.48	6.84

Simultaneously another set of experiments was started at the same experimental sites as mentioned above in order to evaluate the effect of each of N, P and K alone over no manuring (Table 2.10).

In general, application of 150 kg N/ha when applied alone increased the yield of clone S3A3 and TV1 during unpruned and deep skiffed years, respectively.

Long term trial on clones

This experiment (AN 179) was initiated in 1979 at North Bank H.Q. to study the yield response of 16 clones and two biclonal stocks under uniform agro-practices. The yield data for the year 2002 and mean yield for the period 1981-2002 are presented in Table 2.11.

There was significant difference in yield between the clones/seed stocks under study during unprune year. The best performers were TV22, TV23, TV18 and TV20, the lowest yield was recorded from TV21. During the period 1981-2002 the best performers were TV23, TV22, TV19, TV20 and TV26 and the lowest yielder was TV21.

Table 2.11 Yield response of different clones and seed stocks : 2002

Clone/Stock	Yield in KMTH	
	2002 (UP)	Average 1981-2002
TV1	3347	3091
TV9	3514	3055
TV10	3401	3094
TV11	3414	3026
TV12	3249	3160
TV14	3679	3125
TV16	3331	3177
TV17	3431	3192
TV18	3895	3364
TV19	3658	3404
TV20	3844	3398
TV21	2939	2665
TV22	4018	3471
TV23	3996	3547
Stock 449	3378	2992
Stock 450	3506	3089
TV25	3637	3275
TV26	3393	3311
CD (P=0.05)	333	
CV%	5.68	

Trial on biclonal stocks

This trial (AN 172) was initiated in 1979 at North Bank H.Q. plot where yield performance of 9 biclonal stocks were being compared with TV1. The yield data recorded during 2002 and mean yield for the period 1981-2002 are presented in Table 2.12.

Table 2.12 Yield of made tea from seed stocks : 2002

Clone/Stock	Yield in KMTH	
	2002 (UP)	Average 1981-2002
Stock 379	3196	3438
Stock 449	3406	3605
Stock 450	3808	3816
Stock 460	3461	3782
Stock 461	3393	3816
Stock 462	3957	4290
Stock 463	3747	4062
Stock 464	3817	3966
Bari No. 7	3373	3689
TV 1	3479	3897
CD (P=0.05)	431	-
CV%	7.06	-

During the year under review, yield of TS 462 was significantly higher than that of TV1, TS 379, TS 449, TS 460 and TS 461. The yield of TS 379 was the lowest amongst the seed stocks and TV1. It appeared from the mean yield over the period 1981-2002 that TS 462, TS 463 and TS 464 consistently produced higher yields than other stocks.

Another trial (AN 187) was started in 1981 at North Bank H.Q. plot to study the yield performance of four biclonal seed stocks, *viz.*, TS 449, TS 490, TS 491 and TS 492. The yield data for the year 2002 and mean yield for the period 1982-2002 are presented in Table 2.13.

During the unpruned year, there was no significant difference in yield between the Stocks under study. However, all the stocks yielded more than 33 qtls.

The yield performance of another five biclonal Stocks has been studied at North Bank H.Q. plot (AN 244) since 1991. The yield data recorded during the year 2002 are presented in Table 2.14.

Table 2.13 Yield (KMTH) of different seed stocks : 2001 (AN 187)

Stock	2002 (UP)	Average 1982-02
Stock 449	3731	3310
Stock 490	3440	3354
Stock 491	3677	3389
Stock 492	3486	3420
CD (P=0.05)	NS	-
CV%	8.17	-

Table 2.14 Yield (KMTH) of different seed stocks : 2002 (AN 244)

Stock	Yield in KMTH 2002 (LP)
Stock 510	2998
Stock 512	2899
Stock 513	3181
Stock 514	2792
Stock 463	2853
CD (P=0.05)	159
CV%	2.88

During the light pruned year there was significant difference in yield between the biclonal seed stocks under study. The stock 513 produced the highest yield which was significantly higher than all other stocks.

Spacing trial

This experiment was initiated in 1998/1999 at Kolony T.E. (AN 272), Kamakhyabari T.E. (AS 275) and Rosekandy T.E. (C.78) to study the comparative efficiency of a few selected popular spacings. The

yield response of tea to different plant spacings is shown in Table 2.15.

During the final frame formation stage, no significant difference in yield due to different spacings could be recorded in all the sites.

Bringing up of Young Tea

These experiments were started during the period 1998-2002 at Tezpore and Gogra T.E (AN 270), Dikom T.E. (AS 273 & AS 274) and Rosekandy T.E. (C.76 and C. 77) to study the effect of four different methods of bringing up of Autumn and Spring planted young tea. The yield data for the year 2002 are presented in Table 2.16

The trial is in progress and inference will be drawn after the trials are completed.

Table 2.15 Effect of different plant spacings on yield of tea during the year 2002

Treatments	Yield in KMTH		
	AN 272 (+4 yr) TV1 (FFPr 45 cm)	AS 278 (+3 yr) S3A3 (UP)	C.78 (+4 yr) TV1 (FFPr 45 cm)
T1 – 90 cm x 60 cm (18,518 plants/ha)	2130	1581	1991
T2 – 100 cm x 60 cm (16,666 plants/ha)	2026	1456	1687
T3 – 100 cm x 75 cm x65 cm (16,161 plants/ha)	2226	1591	1566
T4 – 100 cm x 70 cm x65 cm (17,316 plants/ha)	2318	1690	1679
T5 – 105 cm x 75 cm x 65 cm (15,686 plants/ha)	1915	1657	1537
T6 – 105 cm x 70 cm x65 cm (16,806 plants/ha)	2241	1653	1659
T7 – 110 cm x 75 cm x 65 cm (15,238 plants/ha)	2144	1475	1561
T8 – 110 cm x70 cm x65 cm (16,326 plants/ha)	2302	1551	1624
CD at 5%	NS	NS	NS
CV% 12.80	6.36	10.35	

Table 2.16 Yield response to different methods of bringing up of young tea in 2002

Treatments	Yield in KMTH				
	AN 270 +4yr., TV23	AS 273 +4yr., TV23	AS 274 +2yr., TV23	C.76 +4yr., TV20	C.77 +4yr., TV20
T1	2063 (FFP-40 cm)	1855 FFP-40 cm)	1209 (FFP-35 cm)	2661 (FFP-40 cm)	2872 (FFP-40 cm)
T2	2885 (UP)	1948 (FFP-45 cm)	1106 (UP)	3093 (UP)	2667 (FFP-45 cm)
T3	2898 (UP)	2041 (UP)	1079 (FFP-45 cm)	3046 (UP)	2840 (UP)
T4	1973 (FFP-45 cm)	1774 (FFP-45 cm)	1111 (UP)	2585 (FFP-45 cm)	2564 (FFP-45 cm)
CD at 5%	238	NS	NS	182	142
CV%	7.03	12.92	22.37	4.65	3.76

AGRONOMY

PLANT NUTRITION

Comparative efficiency of SOP and MOP

The tea bushes of experiments on Potassium, Sulphur and Magnesium nutrition, conducted under SOPIB Project (Ann. Sci. Rep. 2000-01), were deep skiffed in this third year of experimentation. The treatment details and yield of mature teas belonging to the categories of High Yielding (TV-18), Medium Yielding (TV-1) and Low Yielding (TV-11) clones are presented in Table 3.01.

Table 3.01 Effect of SOP and MOP on the yield of high, low and medium yielding mature clonal teas

Treat. No.	Fertilizer doses (kg/ha)			Yield (KMTH)		
	N	P	K	TV18	TV11	TV1
1	80	20	0	1850	1856	1708
2	80	20	80 (KCl)	1979	1848	1887
3	80	20	80 (K_2SO_4)	2117 (7.0)	2049 (10.9)	1907 (10.1)
4	160	50	0	1943	1846	1805
5	160	50	160 (KCl)	2058	2034	1930
6	160	50	160 (K_2SO_4)	2167 (5.3)	2051 (0.8)	2029 (5.1)
C.D. at 5%				230	195	129
C.V.%				7.85	6.69	4.56

Figures in parentheses denote percent increase of yield by SOP over MOP

Results revealed that potassium @ 80 kg K_2O/ha as SOP increased yield upto the tune of 7, 11 and 10 percent over the same level of K_2O as MOP in case of clones TV-18, TV-11 and TV-1 respectively. The increment ranged between 0.8 and 5.3 percent only when K_2O level was enhanced upto 160 kg. Between the two doses (i.e. 80 and 160 kg/ha) there was no significant yield variation in any of the clones under study.

Assessment of made tea quality showed that in all three clones, potassium application in the form of SOP at the rate of 80 kg K_2O/ha produced superior tea compared to the other treatments (Table 3.02).

Table 3.02 Effect of potassium on made tea quality

Treat. No.	Tasters' scores (Mean)								
	Expt. No.3 (TV18)			Expt. No. 4 (TV11)			Expt. No. 5 (TV1)		
	S	Q	V	S	Q	V	S	Q	V
1	56	45	6.5	73	58	7.8	68	48	6.8
2	57	43	6.3	57	53	6.7	64	60	7.3
3	**62**	**50**	**7.0**	**82**	**73**	**8.7**	**82**	**67**	**8.2**
4	58	52	6.8	68	64	7.8	67	60	7.5
5	49	38	6.2	65	52	7.3	68	62	7.7
6	58	48	6.7	62	57	7.3	62	40	7.2

Effect of potassium application on initiation of 1st order laterals of the bush frame of the three types of clones (after DS) was observed and the results are presented in Table 3.03.

Number of first order laterals developed from the deep-skiffed branches of three different clones (TV-1, TV-11 and TV-18) were significantly more in the plots receiving potassium as SOP. However there was no significant variation between the two levels of

application i.e. 80 kg and 160 kg K_2O/ha. (Table 3.03).

Table 3.03 Effect of SOP and MOP on sprouting of tea shoots on deep skiffed (DS) bushes during 2002

Treatment No.	No. of first order laterals		
	TV18	TV11	TV1
1	57	52	51
2	57	60	56
3	66	54	63
4	54	51	53
5	65	56	60
6	67	63	62
C.D. at 5%	9.1	9.05	11.3
C.V.%	9.9	17.3	13.0

In another experiment on young tea where 110 kg and 165 kg K_2O/ha were applied as both SOP and MOP, it was found that application of potassium as SOP produced significantly higher yield over the same level of K_2O as MOP. Between the two doses of K_2O application, there was no significant difference in yield. Even the application of additional dose of Magnesium (@ 10 and 15 kg/ha) did not result in any significant increase in yield (Table 3.04).

Increase in collar diameter upto the tune of 0.39 cm and 0.27 cm was observed in the bushes receiving SOP @ 165 kg and 110 kg K_2O/ha respectively over those plots receiving the same level of K_2O as MOP. However, this increment failed to reach any significant level (Table 3.04).

Biochemical analysis of made tea samples of the young tea experiment revealed that SOP @ 110 kg K_2O/ha significantly increased Theaflavin and Thearubigin contents in made tea resulting in better strength, quality, brightness and total colour of the product.

Table 3.04 Effect of potassium formulations (SOP and MOP) on yield and girth development of young tea (I.P 2002)

Treat. No.	Tr. details (kg/ha) N	P	K	S	Mg	Yield (KMTH)	Collar dia. (cm)
1	110	30	3	3	3	1601	4.90
2	110	30	110(MOP)	0	0	1682	5.33
3	110	30	110(SOP)	40	0	1846	5.60
4	110	30	110(SOP)	40	10	1862	5.60
5	165	50	0	0	0	1566	4.94
6	165	50	165(MOP)	0	0	1697	5.47
7	165	50	165(SOP)	60	0	1860	5.54
8	165	50	165(SOP)	60	15	1932	5.86
	C.D. at 5%					111	0.396
	C.V.%					3.62	4.19

It should be mentioned that SOP contains the essential element S which may be responsible for yield increment, quality improvement and other beneficial effects.

Integrated Nutrient Management

Nutrient dosages made of combinations of inorganic, organic and bacterial formulations were tried in place of conventional fertilizers in an experiment on mature tea (Ann. Sci. Rep. 1998-99). Observations indicated possibility of reducing inorganic fertilizers by supplementing with organic sources and bacterial fertilizers. The treatments were revised in 2002, the new treatments being as follows:

T_1 : Cattle Manure (CM) @ 15 t/ha

T_2 : Inorganic manure @ 150 kg N+ 50 kg P_2O5 + 150 kg K_2O/ha

T_3 : CM @ 15 t/ha + Bacterial fertilizer (Bc.F) [Azotobacter + Azospirillum + Phosphotika each @ 7.5 kg/ha]

T_4 : 100 kg N + 25 kg P_2O_5 + 100 kg K_2O/ha + CM @ 5 t/ha

T_5 : 150 kg N + 50 kg P_2O_5 + 150 kg K_2O + CM @ 5 t/ha

T_6 : 150 kg N/ha + CM @ 10 t/ha

T_7 : Bacterial fertilizer each @ 7.5 kg/ha

T_8 : 75 kg N + 25 kg P_2O5 + 75 kg K_2O + CM @ 10 t/ha

T_9 : 75 kg N + 25 kg P_2O_5 + 75 kg K_2O + CM @ 5 t/ha + (Bc.F) @ 7.5 kg/ha each

The combination of 25% organic manure with 75% inorganic dose produced the highest crop in 2002, although the treatment differences were not statistically significant.

PRUNING AND PLUCKING

Bush Architecture

Survey of Architectural Parameters: Under the 9th Plan Project on Management of Bush Architecture, field survey was conducted in different estates of Assam, Darjeeling, Dooars and Terai (Ann. Sci. Rep. 2001-02). Data on architectural parameters are summarized in Table 3.05.

It is evident from the table that a strong positive correlation existed between yield and number of branches present at different levels. The branches developed at three levels *i.e.* as main stems, frame level branches and primaries developed from the pruned frame were found to maintain a certain ratio in their initiation. The main stem is the original stem of the bush and the frame level branches are the branches coming out from it to form the initial bush frame. The ratio of the branches developed at these three levels varies normally between 1:2:12 to 1:3.5:14. Plants from Assam region tend to follow the second ratio and those from Dooars and Terai tend to follow the former.

Bushes having more branches originating from the main stem normally bear more branches in the next two tiers leading to higher production. High yielding bushes produce more number of pruning sticks (which are also thicker) than low yielding bushes. But the number of branches at the pruning level (pruning sticks) bears a negative correlation with the thickness of branches at the three aforementioned levels. Formation of excessive branches (>20/plant) at the 1st FFP level, however, resulted in the establishment of thinner branches at all levels.

As may be observed from Table 3.06, a positive correlation existed between the weight of bush frame and the total weight of the roots, which suggests the need of better root proliferation to support formation of an ideal frame to sustain higher yield. The length of the roots and their weights were also positively correlated.

Field experiment : An experiment using young clonal plants was conducted to find out the effect of different agrotechniques on the partioning of biomass and development of bush frame in young tea. The experiment was laid out in split plot design. It comprised 60 subplots with five types of planting materials viz. TV-1, TV-23, TV-26, TV-29 and TS-520 subjected to four agro-technical treatments, in three replications. The bushes were planted during May 2001, and the following treatments were applied:

T_1 : Centering at 15-20 cm and tipping at 65 cm. First frame formation prune (FFP) at 35-40 cm in December 2003 Next year Unprune (NUP). Second FFP at 40-45 cm whenever branch thickness at FFP level attains >5 mm.

T_2 : Thumb pruning at 20-22 cm. Rest same as in T_1, but first FFP in January 2003.

T_3 : Centering at 22-25 cm above 4/5 axillary bud/ shoot. Tipping at 70 cm . 1st FFP at 35-40 cm in Jan,2003 – NUP. Final FFP at 40-45 cm (in Jan/Feb,2005).

Table 3.05 Architectural parameters of high and low yielding tea

Region	Section	Yield (KMTH)	Number of branches at			Av. Thickness of branches (cm) at different levels		
			Prune	Frame	Main	Prune	Frame	Main
Terai	HY	3183.6	67.04 (11.8)	10.50 (1.8)	5.70 (1.0)	0.80	2.70	3.92
	LY	1715.6	57.24 (12.7)	9.10 (2.0)	4.50 (1.0)	0.79	2.50	3.38
Dooars	HY	2950.2	70.27 (13.0)	11.75 (2..2)	5.39 (1)	0.88	3.90	4.10
	LY	1724.2	55.63 (11.6)	9.48 (1.98)	4.78 (1)	0.81	2.60	3.80
Cachar	HY	3312.9	65.17 (14.2)	16.75 (3.6)	4.59 (1)	0.68	2.37	3.93
	LY	1463.1	47.94 (12.5)	12.95 (3.4)	3.84 (1)	0.60	2.16	4.20
Upper Assam	HY	3570.5	74.90 (18.6)	9.87 (2.5)	4.02 (1)	0.71	2.80	4.61
	LY	2076.8	65.08 (17.4)	8.29 (2..2)	3.75 (1)	0.68	2.64	3.59
Central Assam	HY	2978.8	71.00 (17.8)	13.20 (3..3)	3.98 (1)	0.69	2.12	4.05
	LY	1978.5	40.10 (12.2)	9.94 (3.0)	3.30 (1)	0.63	2.53	3.60
North Bank	HY	3280.8	77.18 (13.7)	21.89 (3..9)	5.65 (1)	0.59	1.81	3.40
	LY	1985.5	56.05 (16.2)	16.34 (4.7)	3.46 (1)	0.46	1.58	3.10
Darjeeling	HY	1092.6	71.90 (14.9)	15.72 (3..3)	4.82 (1)	0.88	2.64	3.82
	LY	539.5	62.60 (14.5)	12.39 (2.9)	4.31 (1)	0.75	2.17	3.23

Plants of different regions of N.E. India (Mean of different spacings)
HY – High yielding LY – Low yielding
(Figures in parentheses indicate ratio of branches at different tiers)

Table 3.06 Frame and root growth of high and low yielding tea plants of N.E. India

Region	Section	Yield (KMTH)	Frame weight (kg)	Root Weight (kg)	Frame :Root Ratio	Root Length (cm)
Terai	HY	3183.6	7.27	4.23	1.7:1	102.90
	LY	1715.6	6.87	5.02	1.4:1	106.20
Dooars	HY	2950.2	13.50	6.78	2.0:1	158.33
	LY	1724.2	5.60	7.24	1.7:1	153.40
Cachar	HY	3312.9	8.16	4.09	2.0:1	110.56
	LY	1463.1	10.47	6.50	1.6:1	104.56
Upper Assam	HY	3570.5	10.66	5.52	1.9:1	137.10
	LY	2076.8	7.39	4.13	1.8:1	99.23
Central Assam	HY	2978.8	10.18	4.65	2.2:1	123.96
	LY	1978.5	5.25	2.56	2.0:1	69.30
North Bank	HY	3280.8	5.98	4.52	1.3:1	120.10
	LY	1985.5	4.56	3.09	1.5:1	94.75
Darjeeling	HY	1092.6	7.97	7.2	1.1:1	127.79
	LY	539.5	6.74	4.3	1.6:1	117.93

T_4 : Thumb prune at 22-25 cm followed by centering. Selective removal of branches in tiers – (Centre not to be opened up completely) Rest same as in T_2.

Observations recorded in +1 year of experiment (2002) is summarised in Tables 3.07 to 3.10.

Differential response was observed to the initial decentering treatment given to stimulate lateral branches in different clones. TV-1, TV-23 and TV-29 responded better to thumb (lung) prune (T_3 or T_4) as compared to simple decentering at 15-20 cm. More uniformity in branching pattern as an extra advantage was observed in thumb pruning. About 60-70% branches were found within 10 cm above ground level in decentered plants (as shown in Table 3.7), while in lung pruned bushes, they were more evenly distributed throughout the main stem (throughout the 20 cm height).

The maximum numbers of main branches (developed after centering) and maximum number of frame branches (observed during 1st FFP) were found among the TV-29 plants (Table 3.08 and 3.09). Among the various treatments, T_4 (lung pruning at 22-25 cm) exhibited significantly better performance over other treatments in case of TV-29 plants. In case of the TV-1 and TS-520 plants, T_3 (lung pruning at 20-22 cm) proved to be superior, as compared to other treatments (excluding T_1). For TV-23 and TV-26 plants, centering at 22-25 cm (T_2) was found to achieve the best result.

The results confirm our earlier reports that different type of cultivars require separate set of young tea management practices for the formation of well developed frame. While the vigorous clones like TV-23, TV-26, TV-29 should be lung-pruned/ centered at 22-25 cm above ground level, plants like TV-1 or TS-520 exhibit promising results if they are lung pruned at slightly lower height.

Table 3.07 Branching pattern of plants under different treatments (July-August, 2002)

Planting material	Treat No.	Branch No./ plant	% distribution of branch at different height	
			Within 10-20 cm	Within 0-10 cm
TV1	T_1	5.3	69.9	30.1
	T_2	5.6	59.0	41.0
	T_3	5.1	65.1	34.9
	T_4	4.6	61.7	38.3
TV23	T_1	3.6	71.0	29.0
	T_2	3.1	51.0	49.0
	T_3	3.9	61.3	38.7
	T_4	3.6	64.1	35.9
TV26	T_1	3.2	55.3	44.7
	T_2	3.5	64.3	35.7
	T_3	4.9	50.0	50.0
	T_4	3.8	69.5	30.5
TV29	T_1	5.6	61.0	39.0
	T_2	5.3	52.8	47.2
	T_3	5.5	57.3	42.7
	T_4	5.9	55.3	44.7
TS520	T_1	3.5	54.7	45.3
	T_2	4.4	53.9	46.1
	T_3	3.7	53.0	47.0
	T_4	3.2	63.2	36.8

Average yield for the year 2002 under different treatments showed that the clones TV-23, TV-26 and TV-29 were *at par* among themselves, but significantly superior to clone TV-1 and TS 520 in green leaf production during +1 year of plant age (Table. 3.10). During this period, yield response of different cultivars to the various treatments also varied to a considerable extent. TV-1, TV-23 and TS 520 plants produced significantly higher yields when plants were thumb pruned at 20-22 cm (T_2). In case of TV-26 plants, centering at 22-25 cm above ground level exhibited significantly better result as compared to other treatments, while centered plants (T_1 and T_3) yielded more in case of TV-29 plants, irrespective of whether they were centered at 15-20 cm or above. Maximum yield (1375 KMTH) was obtained from +1 year old TV-23 plants, lung pruned at 22-25 cm (T_4).

Table 3.08 Number of main branches per plant under different treatments

Clone \ Treat.	T1	T2	T3	T4	Mean
TV1	5.3	5.6	5.1	4.6	5.1
TV23	3.6	3.1	3.9	3.6	3.6
TV26	3.2	3.5	4.9	3.8	3.9
TV29	5.6	5.3	5.5	5.9	5.6
TS520	3.5	4.4	3.7	3.2	3.7
Mean	4.3	4.4	4.6	4.2	
C.D. at 5%	Clone			1.25	
	Treatment			0.47	

Table 3.09 Mean number of laterals under different treatments

Clone \ Treat.	T1	T2	T3	T4	Mean
TV1	22.4	24.0	21.6	20.6	22.1
TV23	26.9	28.4	28.7	27.0	27.7
TV26	25.3	27.1	31.6	28.6	28.2
TV29	32.2	30.3	30.8	32.9	31.6
TS520	26.4	27.4	28.7	28.2	27.7
Mean	26.6	27.4	28.3	27.5	
C.D. at 5%	Clone			3.87	
	Treatment			1.87	

Table 3.10 Average yield of plants under different treatments in 2002 (KMTH)

Clone \ Treat.	T1	T2	T3	T4	Mean
TV1	770.8	911.1	738.3	809.6	807.5
TV23	1197.6	1362.0	1211.1	1375.2	1286.5
TV26	1041.4	1073.0	1198.9	1095.6	1102.2
TV29	1216.7	1112.4	1203.1	1159.3	1172.9
TS520	731.2	894.2	641.0	778.9	761.3
Mean	991.5	1070.5	998.5	1043.7	
C.D. at 5%	Clone			203.41	
	Treatment			97.99	

Growth pattern of certain TV clones under various types of pruning

Supplementary data generation through further experimentation under Bush Architecture Project was continued (Ann. Sci. Rep. 2001-02). Flushing behaviour of five different clones in the DS year (2002) is presented in Table 3.11. Scrutiny of the table reveals that during the current year (2002), when DS was imparted, maximum bud break (two weeks after DS operation) was noticed among the TV-25 plants, although in the previous (LP) year TV-22 plants showed more bud break (Ann. Sci. Rep. 2001-02) signifying clonal variability following different types of pruning operations. Similar variability was noticed regarding their branching pattern also. In the DS year (2002) TV-25 had more number of primaries per plant, while in LP year, TV-22 plants had more number of primaries.

Table 3.11 Branching pattern and bud-break behaviour of certain TV clones under deep skiff

Characters	Clones				
	TV1	TV11	TV20	TV22	TV25
No. of main stem	4	3	5	4	4
No. of branches at frame level	12	12	12	48	14
No. of primaries (DS level)	48	53	46	59	65
Collar diameter 5 cm above ground level (cm)	29	22	22	18	20
Thickness of main stem (cm)	2.46	2.53	2.23	2.33	2.34
Thickness of frame branches (cm)	1.38	1.22	1.35	1.43	1.38
Thickness of 1st order laterals (cm) at DS level	0.49	0.46	0.51	0.52	0.51
No. of bud break/ plant	10	22	11	26	43
Yield (KMTH) 2002	1856	1972	1786	1946	2020

DS was done on 17.1.02. Bud break was recorded on 30.1.02. Tipping was done in April, 2002

Regarding the collar diameter of the plants, it is observed that the diameter of the TV-22 and TV-25 were the lowest although these two clones yielded more (1946 KMTH and 2020 KMTH, respectively) among all the planting materials under study. The finding suggests that after the bushes attain maturity, collar diameter may not be a good indicator of yield potential. However, the number of primaries developed at the DS or LP level showed positive correlation with yield.

Effect of 'tipping-in materials' on the yield of tea

The effect of various tipping techniques (*i.e.* selective harvest to prepare a convenient plucking surface) was studied on 38 year old plants belonging to six different planting materials incorporating the following treatments on the LP bushes during 2002.

T_1 : Tipping of 2+b shoots at 20 cm;

T_2 : Tipping of only 3+b shoots at 20 cm and

T_3 : Tipping at 15 cm followed by stepping up 5 cm in August.

In all the cultivars under study, tipping at 15 cm over LP (T_3) produced significantly better results over other treatments during the first year of this particular experiment. Numbers of primaries as well as number of plucking points per plant were significantly more in the low tipped bushes as compared to 20 cm tipping. Number of second order laterals per plant were also more in most cultivars

(excluding in TV-1 and TV-17) under T_1. There was no significant variation in the thickness of primaries as well as internode length due to treatment effect contrary to the belief that high tipped bushes produce thicker laterals (Table 3.12).

The beneficial effects of tipping at 15 cm over LP followed by a leaf raise in plucking table during August was well reflected in terms of yield, resulting in significantly higher production over other treatments during the first year of observation. Maximum yield increase to the tune of 47 percent was noticed in TV-19 while the minimum increase (30%) was observed in TS-450 plants due to treatment effect (Table: 3.13).

When the plants were tipped at 20 cm mark, tipping of 3 + b shoots (T_2) produced significantly more yield (9 to 15 percent increase) in most of the clones

Table 3.12 Effect of tipping heights on branch characters of mature tea plants

Planting material	Treat. No.	No. of primaries per plant	No. of secondaries per plant	Thickness of primaries (mm)	No. of plucking points	Internode length (cm)
TV 1	T_1	26	39	4	108	4.0
	T_2	28	33	4	131	3.6
	T_3	34	40	6	176	3.6
TV 11	T_1	23	10	5	115	2.9
	T_2	20	29	5	129	3.5
	T_3	26	40	6	151	3.5
TV 14	T_1	29	15	5	110	3.5
	T_2	29	20	5	115	3.5
	T_3	36	40	6	125	2.9
TV 17	T_1	25	28	4	90	2.8
	T_2	29	22	4	112	3.5
	T_3	30	26	4	130	3.5
TV 19	T_1	20	25	7	85	3.0
	T_2	18	20	7	87	3.0
	T_3	39	43	9	126	3.0
TS 450	T_1	29	20	6	127	3.0
	T_2	35	28	4	135	3.0
	T_3	40	36	6	151	3.0
C.D.-Clone	5%	5.05	5.63	1.9	14.43	NS
	1%	6.78	7.57	2.5	19.38	NS
C.D.-Treat.	5%	3.57	3.98	NS	10.21	NS
	1%	11.75	5.35	NS	13.71	NS

(excluding TV-14 and TS-450) as compared to the normal tipping of 2+b shoots at 20 cm height.

Treatment details:

T_1 : Tipping of 2+b shoot at 20 cm over LP mark

T_2 : Tipping of 3+b shoot at 20 cm over LP mark

T_3 : Tipping at 15 cm over LP mark and raise table by one leaf during August.

Yield trend of the clones irrespective of treatments was in the order of TV-19 > TV-11 > TV-14 > TV-17 > TV-1 > TS-450 (Table 3.13). The highest yielder TV-19 did not have as many plucking points as in TV-1 (highest), signifying that the higher number of plucking points does not necessarily mean higher yield (Table 3.13).

The creep in the plucking table at the end of the first year of experimentation (December, 2002) was measured for each treatment belonging to different cultivars (Table 3.14). In all cases it was observed that the creep was minimum in T_3 (15 cm tipping and step-up).

Table 3.13 Effect of tipping heights on yield (KMTH) of mature tea plants

Planting material	Treatments			Mean
	T_1	T_2	T_3	
TV 1	1611.0	1758.5 (9.16)	2149.8 (33.45)	1839.7
TV 11	1751.0	1925.9 (9.99)	2385.9 (36.26)	2020.9
TV 14	1701.0	1815.4 (6.73)	2359.8 (38.73)	1958.7
TV 17	1592.6	1834.8 (15.21)	2106.5 (32.26)	1844.6
TV 19	1863.7	2120.9 (13.80)	2735.8 (46.80)	2240.1
TS 450	1626.5	1692.6 (4.06)	2117.0 (30.16)	1812.0
Mean	1690.9	1858.1	2309.2	---

(Figures in parentheses indicate % crop increase over T_1)

Table 3.14 Measure of creep (cm) under different tipping heights

Planting material	Tipping 2+b at 20 cm over LP	Tipping 3+b at 20 cm over LP	Tipping at 15 cm raising a leaf in Aug.
TV1	7.6	8.9	4.9
TV11	9.2	9.6	7.0
TV14	6.8	7.4	5.1
TV17	7.7	7.9	6.0
TV19	7.8	6.7	5.7
St 450	6.7	7.7	6.2

SOIL REHABILITATION

The soil rehabilitation experiment conducted with an aim for reducing the gestation period showed that Mancozeb treated plots had more N and Organic C compared to other plots (Table 3.15). Soil K_2O content was the highest in the plots rehabilitated with Guatemala grass while P_2O_5 was maximum in *Trichoderma* + cattle manure treated plots. In most cases, soil pH hovered around 4.5 but soil treated with *Trichoderma* and tea waste had slightly high pH to the tune of 5.13. Planting was done during November,2001, and the plants were finger pruned in June,2002 followed by centering at 15-20 cm above ground level during October,2002. The experiment is in progress.

SHADE TREE

Some non-traditional species of shade trees were studied for their growth and development behaviour and the quality of shade produced. Out of the studied species, only two, viz. *Albizzia richardiana* and *Cassia spectabilis* had shown some promising growth as temporary shade trees.

Table 3.15 Effect of rehabilitation on soil nutrient status (2002) after 3 years of treatment application

Treatment	pH	N (%)	Orc.C. (%)	P_2O_5 (ppm)	K_2O (ppm)
T1	4.55	0.06	0.64	27	75
T2	4.23	0.09	0.75	24	52
T3	4.56	0.07	0.64	22	45
T4	4.47	0.06	0.61	36	41
T5	5.13	0.08	0.68	25	40
T6	4.51	0.07	0.64	28	45
T7	4.50	0.08	0.71	27	51
T8	4.36	0.06	0.68	19	42
T9	4.54	0.07	0.61	27	51
T10	4.51	0.06	0.54	28	47
T11	4.46	0.06	0.64	26	37

T1 – Rehabilitation with Guatemala
T2 – Mancozeb + Sub Soiling
T3 – *Trichoderma* + oil cake
T4 – *Trichoderma* + cattle manure
T5 – *Trichoderma* + tea waste
T6 – Mancozeb + Mukta
T7 – Mancozeb + Paraskhol
T8 – Direct uprooting and replanting
T9 – Rehabilitation with Guatemala + Mimosa
T10 – Rehabilitation with *Cassia tora*
T11 – Fallow

COMPOSITION AND VALUATION OF SHOOT COMPONENTS

A study was undertaken to estimate the contribution of different parts of a plucked shoot, viz. bud, first leaf, second leaf, upper stem (internode between first and second leaf) and lower stem (portion of stem below second leaf) to the quality and valuation of made tea. It was found that the first and the second leaf contributed about 60 percent of total weight of a 2+bud shoot, while a growing bud constituted about 12 percent of the shoot weight. A total of 29 percent was contributed by the stem portion, with the upper stem contributing 12 percent and the lower 17 percent. In terms of valuation, a growing bud contributed 22 percent of the total value, upper and lower stems contributed 19 percent and 17 percent (36 percent of total) respectively and the rest was contributed by the two leaves (Table 3.16). This study was conducted on clone TV-1. Further observations on different planting materials are in progress.

Table 3.16 Effect of shoot components on composition and valuation of made tea

Shoot component	Mean weight (g) (out of 100g)	Tasters' score Strength (Scale of 0-100)	Quality (Scale of 0-100)	Valuation (Scale of 0-10)	Contribution towards valuation (%)
Bud	12.4	57	54	6.7	22
1st leaf	19.5	65	55	6.5	21
2nd leaf	40.6	59	51	6.7	22
Upper stem	11.95	43	29	5.8	19
Lower stem	16.51	31	20	5.2	17

(Figures are average of monthly records for the year 2002)

Tasters' rating		
	Poor	0
	Only fair	20
	Fair	40
	Fairly good	60
	Good	80
	Very good	100

COMPOSITE PLANT

Union of two clones at the vegetative cutting stage to impose a high yielding or high quality scion on a vigorous rooter stock was tried using the following combinations as given in Table 3.17. Out of these, TV 1 on TV 18 (Scion on Stock) was observed to be one of the good combinations.

Table 3.17 Combination of composite plants

Stock	Scion
TV9	TV1
TV23	TV2
TV26	TV17
TV19	TV21
TV23	S_3A_3
TV18	T_3E_3
TV18	TV1

PRUNING LITTERS AND SOIL CONDITIONING

Effect o various techniques on the rate of degradation of pruning litters was studied since December, 2002. In the first treatment pruning litters were chopped with mechanical Shredder and applied back to the plots to monitor its effect on soil organisms as well as the rate of degradation. Manual chopping, keeping the litter *in situ* undisturbed and total removal of litters from plots were the other treatments. The experiment is in progress.

SOIL

Soil/S/2 **Reduction of fertiliser losses (leaching and volatilisation) from soil**

A laboratory incubation experiment was carried out on nitrification inhibition in soil by a few locally available materials. Treatment details were given in Ann. Sci.Rep. 2001-02. These materials were applied in soil by blending with urea in different proportions and incubated at 30°C and 75% field capacity moisture. The extent of nitrification inhibition observed under different treatments are presented in Table 4.01.

Results obtained so far has indicated that urea blended with turmeric at 200:1 ratio could inhibit nitrate formation up to 41% over a period of 30 days after which the inhibitory property of turmeric decreased and became negligible after 90 days. However, urea blended with dry mint powder at 20:1 ratio could inhibit nitrate formation up to 54% and the effect persisted up to 60 days after treatment. Fresh tea waste at 200:1 or 100:1 blended with urea could reduce nitrate formation up to 33% over control and the effect persisted up to 60 days after treatments. Thus this laboratory study showed very

Table 4.01 : Percent nitrification inhibition in soil as affected by various treatment

Treatment	NO3-N in soil (ppm)				% Nitrification inhibition			
Days	15d	30d	60d	90d	15d	30d	60d	90d
Urea @ 100kg N/ha	26	56	51	30				
Urea + Turmeric (200:1)	18	33	37	51	31	41	27	-
Urea + Turmeric (100:1)	20	55	50	52	23	2	2	-
Urea + Turmeric (50 : 1)	26	58	54	52	-	-	-	-
Urea @ 100 kg N / ha	26	56	51	38	-	-	-	-
Urea + dry mint Powder(20:1)	21	26	24	40	19	54	53	-
Urea+dry mint powder(10:1)	16	57	34	37	38	-	-	-
Urea + dry mint powder(5:1)	16	55	50	50	38	2	2	2
Urea @ 100 kg N/ha	26	56	51	38	-	-	-	-
Urea + FTW (200:1)	21	35	34	43	19	38	33	-
Urea + FTW (100:1)	20	35	36	49	23	38	29	-
Urea @ 100 kg N/ha	26	56	51	38	-	-	-	-
Urea + microsul (100:1)	28	49	41	34	-	12	20	11
Urea + microsul (50:1)	30	42	39	50	-	25	24	-
Urea + microsul (25:1)	32	41	32	42	-	27	37	-
Urea @ 100 kg N/ha	26	56	51	38	-	-	-	-
Urea + Eucalyptus(100:1)	23	58	44	31	12	-	14	18
Urea + NOC-A1-22(50:1)	25	35	30	32	4	38	41	16
Urea + NOC - A1-10 (5:1)	28	47	38	31	-	16	25	18

good indication that some locally available plant products could inhibit nitrification in acid tea soils. The promising treatments would be studied under field condition.

Soil/S/5 : **Nutrient dynamics in tea soils**

(a) Phosphate buffering capacity of regional tea soils

Top soil samples (0-15 cm depth) collected from 51 tea sections of different productivity belonging to 30 tea estates of South Bank were equilibrated with KH_2PO_4 solution @ 0,50,100,150 and 200 mg P/kg soil and incubated at 25-30°C and at 1:2 soil: solution ratio for 3 weeks. At the end of the incubation period, the recovery of added P was determined by extracting with Bray-I reagent. Desorption equations were determined by plotting amount of P desorbed against the amount of P added. From the slope of the plot of P desorped vs. P added, the phosphate buffering capacity (PBC) of the soils was determined. Results presented in Table 4.02 show that these tea soils had PBC values ranging from as low as 0.34 to as high as 0.92. This finding indicates that P-release capacity of these soils varied widely. Soil available phosphate was also determined in these soils using Bray-I extractant. The data on PBC and soil available phosphate were grouped into different yield categories to find out if these two parameters had any influence on productivity of tea (Table 4.02).

Table 4.02 : Influence of soil available phosphate and PBC on productivity of tea

Yield level (KMTH)	Available P_2O_5 (ppm)	P-buffering capacity
<1000	51	0.58
1000-1500	42	0.58
1500-2000	58	0.55
2000-2500	55	0.68
2500-3000	77	0.69
>3000	86	0.75

The results indicated a positive relationship between phosphate buffering capacity and yield. A higher soil available phosphate (77-86 ppm) was associated with productivity above 2500 KMTH.

(b) Kinetics of release of non-exchangeable potash :

Laboratory studies on kinetics of release of non-exchangeable potash into available pool were carried out in soils from 27 tea estate of South Bank. The non-exchangeable potash fraction of these soils varied from as low as 61 ppm to as high as 276 ppm. Initial available potash fraction of these soils were, however, found to vary from 32 ppm to 320 ppm.

Soil/L/1 : **Integrated nutrient management**

A field experiment in collaboration with Agronomy Department (T/53) has been in progress at the Tocklai experimental estate on integrated nutrient management since 1998. The experimental plots (130 m^2) each containing 117 bushes of Clone CNM 340 were planted in 1967 at 120 x 90 cm spacing, under shade of *Albizzia odoratissima* with treatments involving use of inorganic, organic and biofertilizers as shown below. Planting was done in randomised block design with three repeats.

Treatment details

T1	100% organic as CM
T2	100% inorganic @ 195 kg N + 50 kg P205 + 164 kg K20/ha
T3	100% organic manure + BF (*Azospirillum, Azotobacter* and Phosphate solubilizing bacteria @ 7.5 kg each/ha)
T4	50% organic + 50% inorganic
T5	25% organic + 75% inorganic
T6	75% organic + 25% inorganic
T7	BF (*Azospirillum, Azotobacter* and Phosphate solubilizing bacteria @ 7.5 kg each/ha)

CM: Cattle manure BF: Biofertilizer

During the period under report, soil samples from the experimental plots under various treatments were analysed. Soil samples collected in April 2002 from three depths (0-15 cm, 15-30 cm and 30-45 cm) were analysed for pH, C, available K_2O, available P_2O_5 and available S. The results are presented in Table 4.03.

Results indicated that none of the parameters except soil available potash under different treatments varied significantly throughout the 45 cm soil profile. The treatment T2 (100% inorganic fertlizers) maintained significantly higher levels of soil available potash at three depths. The soil pH under

Table 4.03 (a) Soil status under Integrated Nutrient Management (0-15 cm depth)

Parameter	Treatment							CD (P<0.05)
	T1	T2	T3	T4	T5	T6	T7	
pH	4.57	4.58	4.70	4.60	4.52	4.58	4.68	0.22
% C	0.72	0.63	0.58	0.54	0.64	0.62	0.68	0.25
Av.K_2O (ppm)	44	105	40	68	62	44	38	37
Av. S (ppm)	20	21	15	27	20	20	18	14
Av. P_2O_5(ppm)	32	38	26	22	32	25	21	21

Table 4.03 (b) (15-30 cm depth)

Parameter	Treatment							CD (P<0.05)
	T1	T2	T3	T4	T5	T6	T7	
PH	4.43	4.58	4.70	4.60	4.47	4.48	4.53	0.16
% C	0.65	0.66	0.64	0.81	0.84	0.75	0.63	0.21
Av.K_2O (ppm)	42	106	36	49	59	38	30	38
Av. S (ppm)	19	27	21	15	25	22	19	8
Av. P_2O_5(ppm)	20	35	22	26	26	24	32	14

Table 4.03 (c) (30-45 cm depth)

Parameters	Treatment							CD (P<0.05)
	T1	T2	T3	T4	T5	T6	T7	
PH	4.50	4.30	4.55	4.40	4.35	4.42	4.48	0.16
% C	0.52	0.50	0.52	0.58	0.63	0.68	0.66	0.23
Av.K20 (ppm)	39	64	30	36	36	19	26	21
Av. S (ppm)	25	28	20	21	18	19	26	7
Av. P205(ppm)	30	26	23	15	21	23	21	13

* Each figure is the mean of three replicates.

this treatment at 30-45 cm depth was found to be significantly lower than treatment T1 (100% organic).

This year (2002), the treatments were changed and the new set of treatments are as follows:

Treatment details

T1	100% organic (equivalent to 150 kg N/ha)
T2	100% inorganic @ 150 kg N+50 kg P_2O_5 + 150 kg K_2O/ha
T3	T1 + BF (*Azospirillum*, *Azotobacter* and Phosphate solubilizing bacteria @ 7.5 kg /ha)
T4	33% organic + 67% inorganic (100 kg N/ha)
T5	100% inorganic + 5t Cattle manure /ha
T6	67% organic + 33% inorganic (50 kg N/ha)
T7	BF (*Azospirillum*, *Azotobacter* and Phosphate solubilizing bacteria @ 7.5 kg/ha)
T8	50% Organic + 50% Inorganic (75 kg N/ha)
T9	50% Inorganic (75 kg N/ha) + 25% Organic + BF (as in T7)

Replication : Three

The treatments were imposed in July this year and a repeat application for biofertilizers was made in September. The experiment is being monitored.

Soil/L/3 : **Studies on heavy metals in tea and tea soils**

During this period (2002-03), 245 green tea shoot samples and 27 made tea samples were extracted for heavy metal analysis. Estimations by AAS were performed for 99 made tea samples for Pb, 18 made tea samples for Cd and 115 made tea samples for Cu.

The results showed that the maximum frequency of occurrence (24%) of lead was in the range of 1.1 – 2.0 mg/kg. The lead content in 58% of the samples analysed were either equal to or less than 2 mg/kg. None of the samples exceeded the PFA permissible limit of 10 mg/kg for lead in made tea.

The cadmium content in majority of the samples (39%) was in the range of 0.21 – 0.30 mg/kg. About 94% of the samples analysed were either equal to or less than 0.40 mg/kg.

It was observed that majority of the tea samples (76%) had copper contents in the range of 11 – 20 mg/kg. About 95 and 99% of the samples were either equal to or less than 30 and 40 mg/kg, respectively.

Bio-availability of heavy metals from soil

A pot experiment was carried out to study bioavailability of heavy metals for soil. Details were reported earlier. During the period under report, thirty TV 23 plants grown in pots containing soil fortified with heavy metals were uprooted and separated into different parts, *viz.*, buds, internodes, young leaves, mature leaves, stems and roots. Analysis of these samples for heavy metals are in progress.

Soil/L/4 : **Soil physical improvement to overcome the problems of compaction, infiltrability, water retention capacity, aeration, structural stability and sub soil improvement for maximum feeder root development**

The details of the field experiment and results obtained one year after implementation of treatments were reported in Ann.Sci. Rep. 2000-01 and 2001-02. Results obtained two years after imposition of treatments are presented in Table 4.04.

This year also the bulk density was found to improve by 7-28% over the control. Aggregate status improved by 30-45 percent. Plucking points and shoot densities (per 100 cm^2 area) are shown in Table 4.06 and were found to be higher in the treated plots.

Table 4.04 : Soil bulk density of the experimental plots

Depth (CM)	Plot 1	Plot 2	% improvement over control	
			Plot 1	Plot 2
0-15	1.43	1.13	9	28
15-30	1.34	1.40	16	13
30-45	1.44	1.33	7	14

Table.4.05 Water stable aggregates of soil in the experimental plots

Plot	Depth (cm)	>2 mm	2-1 mm	1-0.5 mm	0.5-0.25 mm	0.25-2.1 mm	Total
1	0-15	38.07	6.00	6.39	13.48	16.16.1	80.09
	15-30	10.72	21.16	17.09	28.60	14.44	92.06
	30-45	19.58	12.92	14.33	22.48	20.43	91.74
2	0-15	29.76	8.60	10.09	12.39	16.78	77.56
	15-30	14.27	7.71	14.22	23.19	10.96	72.25
	30-45	27.80	9.00	18.44	21.05	20.27	96.56

Table 4.06: Plucking point and shoot densities (per 100 cm^2 area)

Plots	Plucking point	Shoot density
Plot-1	2.3	0.7
Plot-2	2.9	0.9
Control	1.7	0.4

The hydraulic conductivity in the experimental plots was determined *in situ* by Hooghoudt's Auger Hole method and the results are as follows :

Plot – 1 : 1.72 m/day
Plot –2 : 3.40 m/day
Control : 0.17 m/day

Thus, hydraulic conductivity was found to be much higher in the treated plots.

The infiltration rate of soil in the experimental plots was also estimated during this period by double ring infiltrometer and the results are as follows :

Plot – 1 : 4.8 cm/hr
Plot – 2 : 12.0 cm/hr
Control : 1.2 cm/hr

The infiltration rate in the treated plots was more rapid.

Soi/L/5 : **Alternative means of soil rehabilitation for the improvement of soil structure, permeability and organic matter status**

The experimental details and results of plant growth and soil properties were presented in Ann. Sci. Rep. from 1997-98 to 2001-02. The effect of the treatments observed during 2002-03 are presented in Table 4.07.

Table 4.07: Effect on plant growth and soil properties

Treatments		Coller dia (cm)		Org. C (%)		Aggregate (%)		B.D (g/cc)	
		Block 1	Block.2	Block.1	Block.2	Block1	Block.2	Block.1	Block.2
T1	Cowdung @4-5kg/pit	4.36	4.34	0.50	0.81	96.68	89.78	1.50	1.51
T2	OM-I @250/pit	4.02	4.40	0.53	0.71	83.03	86.86	1.52	1.46
T3	OM-II @ 250g/pit	4.32	4.45	0.45	0.64	82.42	78.57	1.52	1.46
T4	OM-I@500g/pit	4.16	g/pit	0.46	0.92	68.94	91.29	1.52	1.49
T5	OM-II @ 500g/pit	4.23	4.24	0.53	0.70	67.63	93.20	1.47	1.48
T6	Trenching + Green crop	4.18	1.19	0.58	0.65	64.25	84.00	1.53	1.50
T7	T1 + Green crop	4.34	3.92	0.45	0.65	87.35	86.76	1.56	1.47
T8	T2 + T3 + Green crop	4.23	4.39	0.57	0.79	74.54	94.29	1.48	1.49
	Mean	4.24	4.28	0.51	0.73	78.10	88.08	1.51	1.48

OM: Concentrated organic manure

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Pl/Bot.1 **New Clones**

Assessment of P463 and P492

Cuttings of the two new clones P463 and P492 were distributed to sixteen tea estates under diverse agroclimatic conditions (Ann. Sci. Rep. 2001-03). Out of these 6 tea estates planted these clones in the field along with best performing clones of the location for yield and quality assessment.

TRA garden series clones

Long term trial of two promising garden series clones L.51 and L.56 from Lengree T.E. was completed under garden condition and both the clones were propagated at Tocklai (Ann. Sci. Rep. 2001-02). Sleeve grown plants were transplanted in the field for assessment of their yield, quality and response to stress under Tocklai conditions.

Pl/Bot. 2 **Selection of superior tea clones**

Green leaf weight and quality testing of selected superior clones under long term trial established in 1997 (Ann. Sci. Rep. 2001-02) were being continued. Out of 20 clones under trial, six produced high yield compared to TV1 and TV30 (Table 5.01) and four clones viz. 650/4, 650/8, 650/14 and 650/19 produced high quality against the controls (Table 5.02).

Pl/Bot.3 **Collection, conservation and evaluation of tea germplasm (Tea Board of India, 9th Plan Project)**

Collection and propagation of tea germplasm

Cuttings of 17 tea germplasms were collected from Dehradun Tea Co. Ltd. (Hurbanswala T.E.) and plantations in different district of Mizoram and propagated at Tocklai during the year.

Table 5.01 Long term trial of promising clones 2002

Clone	Fresh wt. of green leaf (kg/ha)	Yield (KMTH)
650/5	10729	2,414
650/11	10033	2,257
650/14	9749	2,193
650/16	12019	2,704
650/17	9666	2,175
650/19	10073	2,266
650/20	9732	2,190
TV 30	10140	2,281
TV 1	4886	1,099

Table 5.02 Cup characters of the clones under trial (Maximum score = 10)

Clone	Strength	Brightness	Briskness	Quality
650/4	7.5	5.0	5.5	5.5
650/8	8.0	4.5	5.0	5.0
650/14	7.5	5.0	5.0	5.0
650/19	8.8	5.5	5.5	5.5
TV30 (C)	5.0	1.8	2.3	2.5
TV1 (C)	7.0	5.0	5.7	5.0

Characterization of germplasm

Characterization of germplasm accessions in the field gene bank at Tocklai has been continued on the basis of morphological, physiological and molecular parameters.

Leaf morphology of generative clones

Fourteen generative clones, namely 124/48/8, 14/5/35, 19/12/14, 14/12/16, 19/29/2, TA17/1/54,

BOTANY

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650/19	8.8	5.5	5.5	5.5
TV30 (C)	5.0	1.8	2.3	2.5
TV1 (C)	7.0	5.0	5.7	5.0

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HK22/14, S.3A/1, AV2, T-78, 19/35/2, 14/6/28, 19/31/14 and 270/2/13 were studied with tea leaf morphological parameters.

Wide range of variations was observed with regard to various characters. Although specific observation was not recorded, these types of descriptive characters are required to be submitted for national registration.

Physiological Characterization Studies of Germplasm

The photosynthetic efficiency and rate of transpiration of all the 30 TV clones including the two new clones P463 and P492, were estimated from the month of October, 2002 to February,2003. The results are presented in Table 5.03 and 5.04.

The rate of photosynthesis varied significantly ($P<0.01$) between the clones. The monthly variations between clones were also highly significant ($P<0.01$). Interactions between clones and months were significant. Correlation studies between yield and photosynthesis is yet to be done.

Clonal differences in the rate of transpiration were highly significant ($P<0.001$). The monthly variation and the interaction between clones and months were also highly significant ($P<0.001$). Correlation studies between yield and transpiration rate would be studied in the next phase.

Table 5.03 Rate of photosynthesis (μ mol $m^{-2}s^{-1}$) by TV clones

Clones	Months					Mean
	Oct.	Nov.	Dec.	Jan.	Feb.	
TV1	7.80	7.87	6.77	7.37	8.97	7.75
TV2	12.60	11.03	8.77	8.83	9.20	10.09
TV3	13.07	7.00	7.20	10.07	7.47	8.96
TV4	10.60	9.17	6.53	5.80	6.27	7.67
TV5	9.77	7.57	8.10	10.87	10.00	9.27
TV6	10.10	10.50	11.10	6.60	8.53	9.37
TV7	6.37	7.30	9.73	6.40	8.00	7.56
TV8	8.77	7.03	9.00	9.83	9.33	8.79
TV9	8.10	10.30	11.20	6.23	8.53	8.87
TV10	11.83	13.10	11.50	6.33	9.60	10.47
TV11	11.17	9.30	9.93	5.40	8.13	8.79
TV12	9.53	8.43	8.90	8.70	9.47	9.01
TV13	8.67	7.10	8.93	8.93	5.73	7.87
TV14	9.73	11.00	13.70	8.60	8.53	10.31
TV15	9.70	7.80	7.00	7.07	7.20	7.75
TV16	9.20	9.10	7.60	9.60	8.00	8.70
TV17	7.97	10.43	9.33	5.33	7.20	8.05
TV18	10.17	8.23	6.70	8.33	12.27	9.14
TV19	9.60	10.10	8.47	6.73	10.93	9.17
TV20	10.77	6.00	9.50	8.83	9.20	8.86
TV21	12.80	10.30	7.30	6.37	8.87	9.13
TV22	10.23	9.73	9.60	7.97	10.47	9.60
TV23	10.43	10.60	9.20	8.87	9.83	9.79
TV24	9.27	6.63	6.90	6.90	9.93	7.93
TV25	6.60	8.20	7.67	6.53	7.83	7.37
TV26	9.30	9.57	8.87	8.77	8.13	8.93
TV27	6.57	8.77	7.73	4.60	6.67	6.87
TV28	8.07	6.77	7.70	6.13	9.07	7.55
TV29	6.10	9.30	11.10	5.57	8.00	8.01
TV30	7.90	7.10	8.07	7.63	9.73	8.09
P463	10.77	10.90	9.67	9.13	5.07	9.11
P492	9.23	6.60	8.47	5.97	6.00	7.25
Mean	**9.46**	**8.84**	**8.82**	**7.51**	**8.51**	**8.63**
C.D.			5%		1%	0.1%
Clone			1.52		2.00	2.55
Month			0.60		0.79	1.01
Clone x Month			3.40		4.47	5.71

Table 5.04 Rate of transpiration (m mol $m^{-2}s^{-1}$) of TV clones

Clones	Months					Mean
	Oct.	Nov.	Dec.	Jan.	Feb.	
TV1	3.81	3.18	1.83	1.29	4.17	2.86
TV2	5.19	4.17	3.18	2.26	3.99	3.76
TV3	4.59	4.38	2.84	1.96	4.77	3.71
TV4	3.99	3.34	3.35	1.97	2.05	2.94
TV5	4.46	4.60	2.95	1.93	4.28	3.64
TV6	5.10	4.06	2.94	2.16	4.20	3.69
TV7	4.89	3.47	2.99	2.37	4.09	3.56
TV8	4.56	3.90	2.81	1.92	4.11	3.46
TV9	5.12	3.24	2.95	2.15	4.52	3.60
TV10	4.24	3.05	2.77	2.13	4.53	3.34
TV11	5.44	4.49	3.24	1.07	4.17	3.68
TV12	4.50	4.55	3.02	1.01	3.89	3.39
TV13	4.29	4.43	3.38	1.18	3.79	3.42
TV14	4.39	4.30	3.18	1.98	4.43	3.66
TV15	4.88	4.22	3.25	2.19	3.93	3.69
TV16	4.76	4.93	3.20	1.39	4.05	3.67
TV17	5.17	4.48	3.41	1.08	4.00	3.63
TV18	3.75	3.84	2.57	1.26	2.96	2.87
TV19	4.62	3.87	2.95	1.70	4.20	3.47
TV20	4.69	4.02	3.02	1.74	4.12	3.52
TV21	4.54	3.55	2.50	1.38	5.03	3.40
TV22	4.29	4.14	2.61	1.20	3.69	3.19
TV23	4.38	3.59	2.22	1.38	4.11	3.14
TV24	4.53	3.88	3.24	1.87	3.63	3.43
TV25	4.02	3.11	3.11	1.82	2.61	2.94
TV26	4.54	3.10	2.44	1.60	3.23	2.98
TV27	4.55	3.79	3.01	1.89	2.52	3.15
TV28	4.44	3.75	2.91	1.90	3.37	3.28
TV29	4.49	4.17	2.44	1.76	3.55	3.28
TV30	4.17	3.48	3.35	2.01	3.48	3.30
P463	4.64	2.46	4.07	2.90	3.87	3.58
P492	4.40	3.27	3.71	3.16	3.92	3.69
Mean	**4.54**	**3.84**	**2.98**	**1.80**	**3.85**	**3.40**
C.D.			5%		1%	0.1%
Clone			0.31		0.41	0.52
Month			0.12		0.16	0.21
Clone x Month			0.70		0.91	1.17

PI/Bot.4 Study of tea genomic DNA and use of molecular markers in patenting

(a) ISSR analysis

Initially five samples (TV7, TV11, TV16, TV23 and TV25) were analysed following the method already standardized in chickpea in the host laboratory (NCPGR) using two primers (SB-12 and SB-19) having dinucleotide repeats and one primer (SB-11) having trinucleotide repeats. Standardization was done by varying the amounts of chemical components and the PCR cycling conditions.

Primers	Sequence
SB - 12	GCTCTCTCTCTCTCTCTCTCT
SB - 19	GCACACACACACACACACACA
SB - 11	GCTTCTTCTTCTTCTTCTTCTT

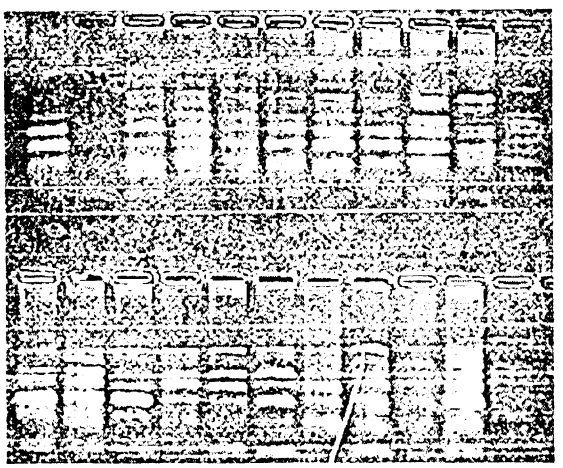

Fig. 5.01 ISSR Banding Profile of TV clones

Good PCR amplification and DNA polymorphism was observed in 19 tea cultivars out of 20 used for studies using SB-11 primer (Fig. 1). However, more number of primers are required to be included for obtaining a clear picture of genetic diversity in tea through ISSR marker analysis.

b) RAPD marker analysis

PCR-based RAPD analysis continued covering diverse types of tea germplasm including 7 Darjeeling clones (available at Tocklai), 5 wild types collected from New Botanical Area – *Camellia sasanqua, C. drupifera, C. roseflora, C. japonica and C. irrawadiensis* and 9 tea germplasms from upper Assam. A few primers were tested for the PCR experiments, which exhibited good DNA polymorphism. More primers were included to have a clear picture of a molecular genetic diversity in tea.

c) Made tea genomic DNA isolation and PCR analysis

Considering the importance of protection of Indian tea in the international market, an attempt was made to standardize the protocol of genomic DNA isolation from made tea, which would be required for PCR-based DNA marker analysis for the development of molecular documentation system, necessary for accurate identification of the finished product. Despite difficulties in isolating good quality genomic DNA due to high temperature involved during processing of tea, limited success could be achieved in both DNA isolation and PCR amplification of made tea DNA. Further work is in progress.

PI/Bot.5 **Development of polyploid tea.**

(i) *In vitro* polyploidy : After unsuccessful effort at hardening and establishment of the putative colchiploid tea plantlets (Ann. Sci. Rep., 2001-2002) the situation was reviewed and discussed with experts. As per the recommendations, some modifications were made in the culture room conditions. Alteration of photoperiod in the culture room was also tested. Increase of photosynthetically active radiation (PAR) in the culture racks for better hardening prior to the subsequent steps of rooting and grafting was also tried.

Colchiploid tea shoots were further multiplied through frequent sub-culturing in fresh media. The strong and healthy shoots were used for rooting experiment (Table 5.05).

(ii) Chemical mutagen : To induce polyploidy with the use of chemical mutagen, 'colchicine' was applied in different concentrations to the developing seeds at different stages of growth. Test solutions were injected to the liquid endosperm of the immature seeds with the help of a very fine syringe. Success in the development of seeds after the treatments is shown in Table 5.06.

Table 5.05 Putative colchiploid shoots under *in vitro* culture

Concentration of colchicine in the media	Number of micro shoots	Number of mature shoots	Number of shoots in the rooting media
0.005%	~1120	~112	32
0.010%	~ 240	~ 50	32
0.025%	~ 25	~300	48
0.200%	~ 540	~215	37

Table 5.06 Number of seed development after colchicine treatments

Concentration of colchicine (%)	Number of seeds treated	Number of seeds eveloped	% success of seed develop-ment
0.005	175	35	20
0.015	177	00	00
0.025	196	00	00

PI/Bot.6 **Wide cross : interspecific hybridization**

For the development of hybrids different parental combinations of different species of *Camellia* were crossed artificially (Ann. Sci. Rep. 2001-02). Taking *Camellia sinensis* as the female parent crossing was done with three species of *Camellia viz.*, *irrawadiensis, sasanqua, rosiflora*. Initially fruit set was observed but no mature seed could be obtained. This effort would be continued considering the past success in crossing tea with non cultivated *cammellias*.

PI/Bot.7 **Hybrid tea**

Progenies planted in the germplasm plots (Ann. Sci. Rep. 2000-01) which were obtained from six different crosses (S3A/1 x TV17, 14/5/35 x 124/48/8, HK22/14 x BJ 2, TV30 x TA 17, 14/12/16 x 124/48/8, TV24 x TV17) of selected vegetative and generative clones during the year 1998-99 and 1999-2000 were growing satisfactorily. Observations on the growth behaviour, phenotypic expression of parental characters etc. were being made. Physiological characters would be assessed during the next growing season.

For the development of quality planting materials, artificial pollination was done during November-December, 2002 and fruit set recorded (Table 5.07).

Tabl 5.07 Hybridization experiments showing parental combinations

Parental combination	Number of flowers	Number of fruit	% of success
TV1 x HK 2315	143	54	38
TV19 x HK 2315	151	63	42
TV19 x Barmajan2	164	67	41
TV19 x Barmajan20	125	71	57
TV1 x Shan tea (Vietnam)	11	1	9

PI/Bot.8 ***In vitro* screening of tea somaclones for resistance against red rust diseases**

For screening red rust disease tolerant/resistant somaclones, *in vitro* derived embryogenic calli were cultured in MS (Murashige and Skoog, 1962) based 5Y solidified medium supplemented with filter sterilized extract from red rust infected tender stem in different concentration (Ann. Sci. Rep., 1998-99 to 2000-01). The toxicity was found to be prominent above 100ml extract (toxins equivalent to 100gm fresh materials) per liter of medium, where inoculated calli susceptible to toxins degenerated. The shoots regenerated from the red rust resistance calli were recultured in the conditioned medium supplemented with infected shoot extract at a concentration of 125 ml/l for further screening. The survived shoots were multiplied through frequent sub-culturing in micropropagation medium and the strong, healthy shoots were selected for hardening and establishment in the field through micrografting (Table 5.08). After establishment in the field, their tolerance to red rust disease will be studied.

Table 5.08 Number of red rust tolerant shoots in culture

Treatment	Tolerant conditioned medium	Shoots in regeneration media	Number of of healthy shoots
½ MS media + 125 ml/l crude extract	70	~ 400	~ 25

PI/Bot. 9 **Extraction, identification, quantification and utilization of endogenous growth hormones in tea**

The effects of plant growth regulators (PGR) on yield and dry weight were reported in the Annual Scientific Report 2001-02. Effect of PGRs on the endogenous level of IAA, rates of photosynthesis and transpiration were studied during the year, 2002-03. Foliar applications of growth regulators viz.

gibberellin (GA_3), indole-3-acetic acid (IAA) and cytokinin (Kin) @ 100 ppm each were made separately in the months of March, April, May, September, October and November on mature bushes of three popular clones: TV1, TV17 and TV23. The change in endogenous IAA level was determined in the three clones by using HPLC from April to December. The mean values are presented in Table 5.09.

Application of GA_3 increased the endogenous level of IAA significantly in every month except June. Significant effect of IAA application on endogenous IAA improvement was also observed in the months of April, August, September, October, November and December. The level of IAA started to decline from the month of October and attained minimum level in December.

Table 5.09 Effect of foliar application of GA_3, IAA and Kin on endogenous level of IAA ($\mu g\ g^{-1}$)

Months	Treatments				CD at	
	Control	GA_3	IAA	Kin	5%	1%
April	2.50	5.62	5.57	3.64	0.46	0.62
June	1.45	1.42	1.19	0.92	0.10	0.14
July	2.26	2.55	1.78	1.05	0.25	0.34
Aug.	0.45	0.74	0.54	1.03	0.04	0.05
Sept.	1.30	1.67	1.70	1.25	0.08	0.11
Oct.	0.09	0.13	0.16	0.08	0.01	0.01
Nov.	0.08	0.13	0.14	0.07	0.01	0.01
Dec.	0.03	0.05	0.05	0.04	0.01	0.01

Effect of foliar application of these growth regulators on photosynthesis and evapo-transpiration rate was evaluated in the field grown mature bushes of the same TV1, TV17 and TV23 clones using the Portable Photosynthesis System. The results are presented in Tables 5.10 and 5.11.

Table 5.10 Effect of PGRs on photosynthesis (μ mol $CO_2\ m^{-2}S^{-1}$)

Clones	Treatments				Mean
	Control	GA_3	IAA	Kin	
TV1	12.64	13.56	12.22	14.10	12.13
TV17	13.44	14.78	14.42	13.68	14.08
TV23	15.82	12.54	8.36	8.82	11.39
Mean	12.63	13.63	11.67	12.20	
C.D. at		5%	1%		
Clone(C)		2.07	2.77		
Treatments (T)		2.39	3.19		
C X T		0.62	0.82		

Table 5.11 Effect of PGRs on evapo-transpiration (μ mol H_2O vapour $m^{-2}s^{-1}$)

Clones	Treatments				Mean
	Control	GA_3	IAA	Kin	
TV1	3.95	6.38	6.99	4.57	5.47
TV17	5.27	5.49	5.52	7.07	5.84
TV23	7.05	4.91	4.63	3.70	5.07
Mean	5.42	5.59	5.71	5.11	
C.D. at		5%		1%	
Clone (C)		0.31		0.41	
Treatments (T)		0.36		0.47	
C X T		0.62		0.82	

PI/Bot.10. **Screening of genotypes for water logging and drought tolerance**

The moisture gradient between leaf and soil causes absorption of soil water during the period of moisture stress. Further, tissue water relation that has been measured frequently is the relationship between relative turgidity and water potential of

leaves. An attempt was made to assess the water release characteristics in leaves of four drought tolerant (DT) and susceptible (DS) TV clones through simultaneous measurement of leaf water potential (LWP) and relative water content (RWC) in two adjacent leaves of a growing shoot after different hours of withering at room temperature. Figures 5.02 and 5.03 show the relation between RWC and LWP in DT and DS clones.

Figs. 5.02 and 5.03 show that DS clones wither faster than DT clones. Under similar LWP, the tolerant clones exhibited more RWC. Degree of tolerance to drought of a cultivar depends on RWC at low LWP since under similar degree of water stress resistance to tissue desiccation was more in tolerant group of clones.

PI/Bot.11. **Selection of superior shade trees**

Anadenanthera peregrina (L.) Speg., an exotic evergreen type of tree belonging to the family Fabaceae (Leguminoseae), is a promising shade tree for N.E.Indian tea plantation. It was reported that the propagation of this species was not possible (Memorandum No. 30, pp 80). An effort was made to multiply the species through seed propagation. With this objective pods were collected in the third week of March, 2003 from the only available plant at Borbhetta Experimental Field. The plant is more than 60 years old and free from pests and diseases. The seeds were separated by pounding the pods. Initially seeds were soaked overnight in 100 ppm GA_3 and germinated *in vitro* where 100 % germination was observed. Later the seeds were soaked in clean water and germinated both in laboratory and in the seed nursery. Germination up to 80% was observed. Soaking more hours was found detrimental as the germinating seeds detached the seed coat. Those seeds without seed coat easily infected by fungus when planted in soil and damage the tender seedlings. Seeds with intact seed coat after soaking produced healthy seedlings. The seedlings were now growing in sleeves and shade nursery where growth would be assessed for their field performance.

PI/Bot.12 **Tissue culture of shade trees**

The unsuccessful attempts of shade tree vegetative propagation using nodal cuttings of growing shoots with and without pre treatment (Ann. Sci. Rep. 1999-2000) led to initiate the *in vitro* propagation studies of *Albizzia odoratissima* and *A. chinensis* and multiple shoot proliferation obtained in MS based medium as stated in the Ann. Sci. Rep., 2000-2001, 2001-2002, from the explanted root segments. Experiments were being continued with modified medium to enhance proliferation of strong healthy shoots.

Considering the difficulties in germination of the seeds of a promising shade tree.*Anadenanthera peregrina* (Synonym *Piptadenia falcata* Benth), a native of Brazil and Paraguay belonging to the family Fabaceae (Sub family-Mimoseae), was being grown at Borbhetta T.E., as the only plant.

Tocklai was included in the tissue culture programme. The canopy of this species appeared to be ideal with small leaves and very short leafless period. In the first effort seeds were collected at different stages of growth and simultaneously cultured *in vitro* in culture medium as well as in pots filled with soil and sand mixture for *in vivo* germination. The seeds of very young pods failed to germinate *in vivo* but germinated easily in *in vitro* culture medium (Fig. 4). Various parts of the *in vitro* germinated seedlings were used as explant for culturing. Microshoots were developed from cotyledonary explant through embryogenesis. The regeneration media was modified for faster growth of the microshoots.

PI / Bot. 13 ***In vitro* culture in tea**

Long term trial (LTT) of vegetatively propagated tissue culture-derived plants (second generation)

Yield and quality performances of ten tissue culture

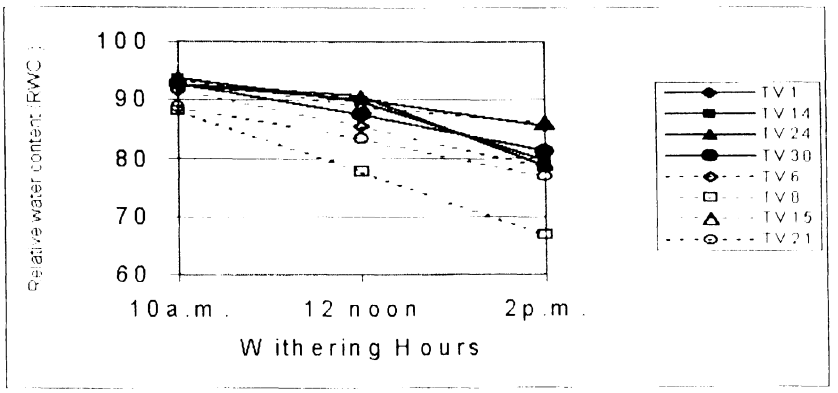

Fig 5.02 (a). Relative water content (RWC) of four drought tolerant (DT) and four drought susceptible (DS) TV clones at different hours of withering.

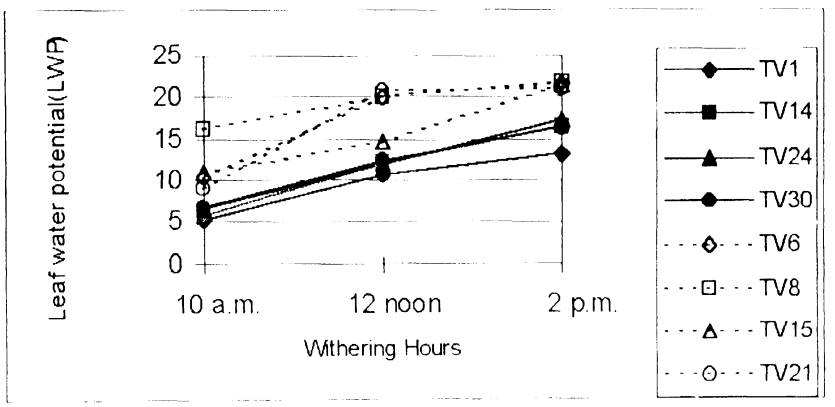

Fig 5.02 (b). Leaf water potential (LWP) of four drought tolerant (DT) and four drought susceptible (DS) clones at different hours of withering.

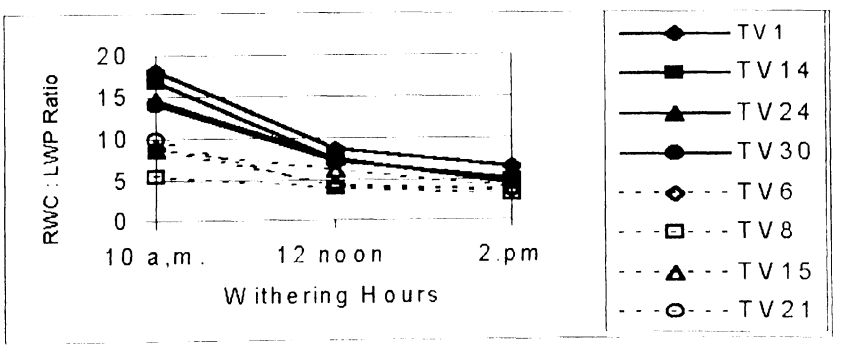

Fig 5.03. Relative water content (RWC) : Leaf water potential (LWP) Ratio of four drought tolerant (DT) and four drought susceptible (DS) TV clones at different hours of withering.

derived clones (527/1 to 527/10) under LTT (Ann.Sci. Rep., 1999-2000, 2000-01, 2001-02) were assessed in one pruning cycle of three years. Clone 527/4 indicated for higher liquor strength and liquor quality with higher valuation against TV1. Another clone 527/9 was marked for higher liquor strength. In respect of yield potentiality clones 527/5, 527/6, 527/7 and 527/8 were marked.

To study the stability of assessed characteristics in subsequent generations the marked clones were rested for the production of cuttings for vegetative propagation.

Propagation of selected somaclones

Another set of 42 tissue culture derived somaclones including the 14 selected last year (Ann. Sci. Rep., 2001-02), were marked as promising based on the initial observations in respect of some physiological and morphological parameters, tolerance to pests and diseases etc. Cuttings taken from the bushes were propagated (Table 5.12). Long term trials with the established plants were raised for assessment of yield, quality etc.

Table 5.12 Propagation of selected somaclones

Stock No.	No. of cuttings propagated	Stock No.	No. of cuttings propagated
651/12	14	651/47	29
651/13	17	651/48	41
651/18	19	651/50	16
651/21	23	651/51	40
651/22	18	651/52	23
651/23	32	651/53	50
651/28	14	651/54	30
651/26	26	651/55	70
651/32	26	651/57	35
651/34	31	651/58	38
651/35	18	651/59	38
651/36	30	651/60	57
651/37	26	651/61	37
651/38	29	651/62	52
651/40	38	651/36	30
651/41	28	651/67	18
651/42	57	651/70	13
651/43	38	651/73	35
651/44	32	651/74	35
651/45	26	651/76	30
651/46	36	651/70	70

Somaclonal Variations

Being encouraged with the reliable performance of the callus culture derived somaclones of earlier experiments (Ann. Sci. Rep., 1997-98 to 2001-02) callus culture studies were continued. Cotyledon slices and zygotic embryo sections of seed stock P463 and P492 were included as explant in a new set of callus culture experiment. Callus proliferation from the explanted tissues was obtained.

***In vitro* rooting in solid media**

From the earlier cultures batches of shoots were regenerated and the healthy shoots cultured in modified ½ MS solid rooting media supplied with IBA in different concentrations. Long and strong roots were developed from the cut ends of the cultured shoots. Results are shown in Table 5.13.

Table 5.13 *In vitro* rooting in solid media

Media	Shoots cultured (No.)	Root developed (No.)	% success
½MS+IBA 100µM	50	22	44
½MS+IBA 175µM	50	41	82
½MS+IBA 250µM	50	12	24

Water stagnation tolerance study

Through repeated culturing in fresh regeneration medium the population of water stagnation tolerant shoots, developed from the water stagnation tolerant tissues (Ann. Sci. Rep., 1999-2000, 2000-01) was increased. The healthy shoots transferred to rooting medium (Ann. Sci. Rep., 2001-02) showed good rooting (Table 5.14) but failed to establish in pots

filled with sand : soil (1:1).

Micro Shoot Grafting : *in vitro* derived shoots (Scion) on sleeve grown seedlings (Stock)

In this experiment 10-12 months old sleeve grown seedlings of three biclonal seed stocks viz. TS 491, TS 506 and TS 463 were used as root stocks. Tissue culture derived shoots with three to four leaves were grafted (Fig. 5.05) in the middle of March, 2003 and kept under shade. Grafted scions were looking healthy.

Table 5.14 Rooting of water stagnation tolerant shoots

Duration of water stagnation of embryogenic calli	No.of micro shoots developed from water stagnation tolerant calli	No.of mature shoots	No.of rooted shoots in modified rooting media
3 Months	~ 742	~ 330	40
6 Months	~ 504	~ 210	54

Project L 13 **Protoplast culture**

Proto-clonal variations in the shoot population derived from protoplast culture were more prominent in the hardened shoots under improved light conditions (increased intensity and higher day length) in the culture rack (Ann. Sci. Rep., 2000-01, 2001-02). Modifications have been made in the regeneration media to develop strong healthy shoots. The shoots would be utilized in the micrografting experiments for establishment in the field.

NMITLI Project: Niche-pathway engineering in tea

Leaf samples of selected germplasms were provided to the Biochemistry Department for analysis of catechines.

Additional Works-1

Evaluation of Commercial Growth Regulators

Two commercial growth regulators, Green Miracle and Amity, received from TRA Associated Members were evaluated in the field for crop yield. The trial was conducted for one pruning cycle of three years. The results are given in Table 5.15.

Table 5.15 Effect of Green Miracle and Amity on yield (Kg/Plot)

Clone	:	T3E/3
Year of Planting	:	1968
Spacing	:	120 x 90 x 60 cm
Plants/plot	:	60
Exptl. Design	:	RBD

Treatment	Year			Mean
	2000 (UP)	2001 (LP)	2002 (DS)	
Control	63.01	41.83	56.33	53.73
Standard	67.56	43.80	60.58	57.31
G.Miracle (3.30 ml/ l)	61.91	42.47	59.13	54.50
G.Miracle (4.95 ml/ l)	68.02	46.67	59.87	58.18
Amity (5.71 ml/5 l)	64.36	44.43	56.40	55.06
Amity (7.14ml/5 l)	66.43	44.07	56.08	55.53
Amity (8.56ml/5 l)	60.51	41.97	54.02	52.16
Standard – Urea + Zinc spray				

C.D. at	5%
Year (Y)	2.69
Treatment (T)	4.09
Y x T	4.29

None of the two products could increase crop significantly over the standard.

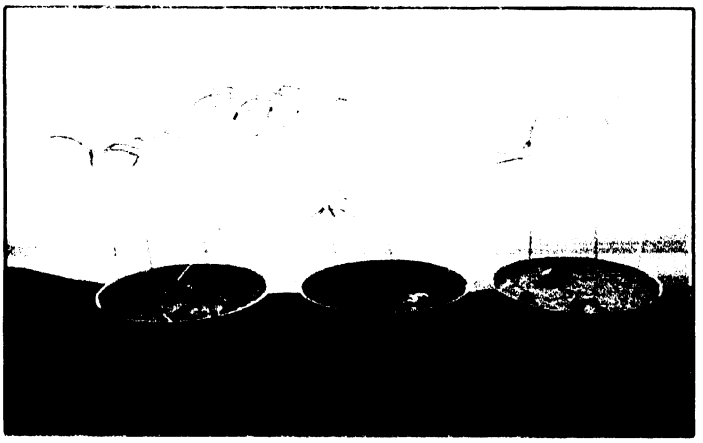

Fig. 5.04 Seedlings of *A. peregrina* from *in vitro* germinated seeds

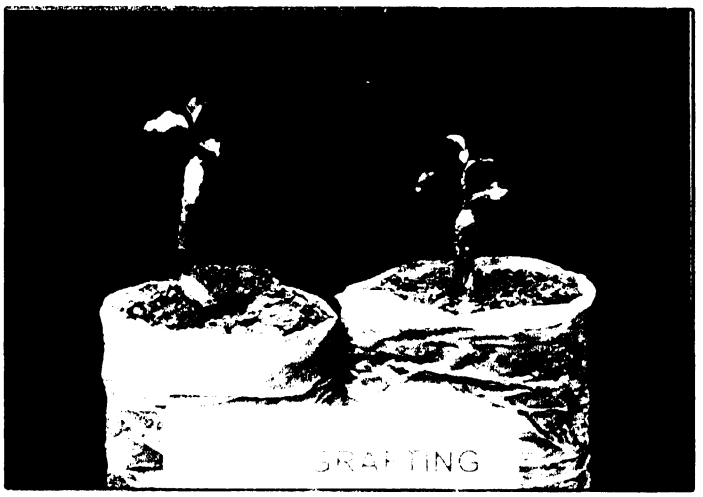

Fig. 5.05 Micrografted tissue culture derived shoots on seedlings of P-463 (Stock)

Soil nitrogen and zinc content were quantified in the control and standard plots from top and sub soils to see if there was any significant deviation of these two elements in soil within the experimental site (Table 5.16).

Table 5.16 Soil nitrogen and zinc contents in experimental plots

Site	Sample	N (%)	Zn (ppm)
I	Control (Top)	0.09	11.06
	Control (Sub)	0.08	6.90
	Standard (Top)	0.10	12.46
	Standard (Sub)	0.08	7.33

In site I, there was no significant difference in soil nitrogen and zinc content in the control and standard plots. But the yield was significantly higher in the standard plots indicating the effect of application of urea and zinc.

Additional Works-II

Problem of Plant mortality Ghillidary Tea Estate

Mature tea plants of different age groups and different clones at various sections of Ghillidary Tea Estate showed the symptoms of nitrogen and magnesium deficiency (chlorosis), leaf potassium deficiency (scorching), defoliation and subsequent death. Affected plants from section No. 42 were uprooted. Examination showed deep initial planting, lenticell formation in the roots, stickiness of soil to the roots, poor feeder root development, leaf chlorosis and scorching, inadequate size of pruning stick thickness etc. On the basis of these symptoms, a look-see trial with the following treatments in collaboration with the Plant Protection Department was laid out during August, 2002 at section No 42 to see if the plants could recover. The treatments were as follows:

T1 : Control (No treatment)

T2 : Foliar application of urea @ 2% + Potash (MOP) @ 2% - 4 rounds at 3 weeks intervals.

T3 : Foliar application of urea (2%) + Potash (2%) + Magnesium (1%) + Boron (0.05%) – 4 rounds at 3 weeks intervals.

T4 : Forking + Cattle manuring @ 3 tons/ha + foliar spray (urea 2% + Potash 2%)

T5 : Normal manuring as per the garden practice (in split dose)

T6 : Same as (2) with two rounds of Hexaconazole 1:1000 at 15 days interval

T7 : Same as (3) with two rounds of Hexaconazole 1 : 1000 at 15 days interval

T8 : Same as (4) with 2 rounds of Hexaconazole 1: 1000 at 15 days intervals

T9 : Same as 5 with 6 rounds of Hexaconazole 1:1000 at 15 days intervals

T10 : Same as 4 with soil application of *Trichoderma* (2L/plot)

T11 : Same as 5 with soil application of *Trichoderma* (2L/ha)

Treatments were applied during August to October of the year 2002 in monthly intervals. Most of the treatments responded to a great extent as compared to control. However Treatment No. 8 was found to be most effective. Prior to the treatment application, root starch was estimated from healthy and affected plants of each plot. The affected plants showed high level of starch accumulation as compared to the healthy plants, indicating inefficient use of root starch. Due to heavy soil, growth of moss was observed particularly in the collar region. Affected patches should be uprooted and rehabilitated with Guatemala grasses after proper land preparation.

The cause of all these symptoms was the heavy soil. The treatment No.8 should be considered as stopgap measures and not as a permanent solution.

PLANT PROTECTION

PP/S/1 **Integrated management of *Helopeltis***

The second phase of the trials using new generation pesticides *viz*., Lambda-cyhalothrin 2.5 EC, Beta-cyfluthrin 0.25 EC, Imidacloprid 17.8 EC, Ethofenprox 10 EC, Oxydemeton methyl 25 EC and Cartap hydrochloride 50 SP was completed. The pesticides were applied in four different combinations in four experimental blocks having severe infestation of *Helopeltis*. The combination of pesticides, Lambda-cyhalothrin (during March), Oxydemeton methyl (during April), Ethofenprox (during May) and Cartap hydrochloride (during June) gave the best result with 96.4% control of the pest. The results are given in Table 6.01.

PP/S/2 **Non-conventional control of foliar disease**

Basing on the results obtained last year for controlling blister blight disease of tea by using extracts of *Cassia tora*, a herbal product, another field trial was laid out this year with the same herb and some other treatments to see their efficacy in controlling the disease.

The trial was conducted at Pandum T.E. in Darjeeling with two treatments of *C. tora* one in form of water extract and the other in solvent extract. One treatment with *Equisetum arvense*, a local herb of Darjeeling, known as 'Horse tail', in two concentrations and another treatment with Copper oxychloride mixing with two stickers were incorporated.

Treatments were imposed in randomised block designed plots with 3 replications having 15 bushes in each repeat. Four rounds of treatments were applied at weekly intervals immediately after a plucking round. Observations were made on the fresh disease incidence after every plucking round and the final post-treatment assessment on disease

Table 6.01 Percent control of *Helopeltis*.

Pesticides	Month	Block			
		I	II	III	IV
P1:Lambda-Cyhalothrin 2.5EC					
P2:Beta-cyhalothrin 0.25 EC @1:1000	March (2002)	P2 (41.7)	P3 (38.6%)	P4 (37.5%)	P6 (40.6%)
P3:Thiomethoxam 25 WG @ 1:4000	April	P5 (22.6%)	P6 (20.6%)	P2 (12.8%)	P7 (21.4%)
P4:Imidacloprid 17.8 EC @ 125 ml/400 L	May	P1 (9.6%)	P5 (8.5%)	P6 (5.5%)	P6 (9.9%)
P5:Cartap–Hydrochloride @ 1:1000	June	P7 (5.6%)	P2 (4.4%)	*C.carnea*	P5 (4.6%)
P6:Ethofenprox 10EC @ 1:1000					
P7:Oxydemeton Methyl 25 EC @ 1:400	July	Control (95.4%)	Control (94.6%)	Control (95.4%)	Control (96.4%)

(Figures in the parenthesis indicate pre-treatment infestation)

severity was made after two weeks of the last round of treatment application. The observations were made by collecting 100 plucked shoots randomly from each treatment. Observations are recorded in the Table 6.02.

The results presented in the table indicates the superiority of the solvent extract of *C. tora* over its water extract in controlling the disease where 74.4 and 76.4% reductions of the disease were obtained on counting the infected shoots and number of blisters respectively.

Validamycin an antibiotic formulation, could also reduce the disease intensity in the range of 63.3 to 70.9% over control.

Water extracts of the herb *E. arvense* also showed good results by reducing the disease upto 68.5%.

Copper oxychloride mixed with two different stickers provided more than 80% control of the disease in terms of both on number of infected shoots and blisters.

PP/S/3 **Seed pathology** :

The following treatments were imposed in the experimental sites of the infected seed bari of Upper Assam during the year : January-February – Carbendazim @ 1:400; March-April –Hexaconazole @ 1:1000; May-June – Carbendazim @ 1:400; July-August – Hexaconazole @ 1:1000 and September-November – *Trichoderma* broth (5%). The experimental site was also kept under reduced dose of nitrogen i.e. 50 kg/ha. Remarkable reduction of the problem was observed after the imposition of the treatments.

Table 6.02 Effect of non-conventional treatments on control of blister blight disease.

Treatments with dose	On infected shoots		On blisters	
	Mean disease incidence	% reduction over control	Mean disease incidence	% reduction over control
1. Water extract of *C. tora* (100 g/10 litres)	5.0	44.4	7.3	42.5
2. Solvent extra of *C. tora* (25 ml/10 litres)	2.3	74.4	3.0	76.4
3. Validamycin (10 ml/10 litres)	3.0	66.7	5.7	70.9
4. Validamycin (6.6 ml/10 litres)	3.3	63.3	5.7	70.9
5. *Equisetum arvense* Water extract 10% (1 kg/10 litres)	3.3	63.3	4.0	68.5
6. *E. arvense* 5% (1/2 kg/10 litres	5.3	41.5	8.3	34.6
7.COC + Sticker I (25 g + 6 ml/10 litres)	1.3	85.5	2.0	84.2
8. COC + Sticker II (25 g+ 6 ml/ 10 liters)	1.0	88.9	2.0	84.2
9. Control (Untreated)	9.0	-	12.7	-

PP/L/1 **Integrated Management of Termite** :

Three years' observations on the ongoing termite control trials at four gardens in Cachar were made. The results (Tables 6.06-6.07) showed that the newer termiticide Imidacloprid 17.8 EC @ 670 ml/ha gave maximum (79-82%) control of the pest at different trial sites. Efficacy of Kanodane was also as high as Imidacloprid. Another newer termiticide Thiomethoxam 25 WP gave the maximum control of 80% @ 500 ml/ha at Pathemara and Rosecandy T.Es.

Tables 6.08-6.09 show the results of the two years' post-treatment observations on termite at Durrung and Nahoroni T.Es. in the North Bank. The new molecule Imidacloprid 17.8 EC @ 670 ml/ha gave 79-80 per cent control. Another newer termiticide Thiomethoxam 25 WG @ 400 g/ha gave maximum 79 and 78 per cent control at Durrung and Nahoroni T.Es., respectively.

PP/L/3 **Pesticide residue study** :

Method development work on new generation pesticides, namely 1. Omite 57 EC (Propargite), 2. Bulldock 0.25 SC (Beta-cyfluthrin) and 3. Confidor 200 SL (Imidacloprid) are in progress. During the period, 72 black tea samples, 18 pesticide samples and 4 organic manure samples received from different member gardens were analyzed. The black tea samples were analyzed for pesticide residues content with multiresidue analysis method whereas the pesticide and organic manure samples were analyzed for contamination as well as for active ingredient content. The pesticide residues of the analyzed tea samples were found to be below MRL fixed by EU. Out of 18 pesticide samples 2 samples were found to contain other pesticides than the actual formulation. The active ingredient contents of all the analyzed pesticides were found to be at par. The organic manure samples were found to be free from pesticides.

PP/L/4 **Bioefficacy of pesticides** :

Red spider : Bioefficacy of Sulfur formulations *viz.*, Flowable sulfur 40% @ 1:200 and 1:300; Micros 40% @ 1:200 and 1:400; Microsul 52% @ 1:400 and Stoller 72% @ 1:100 and 1:200; gave 72-81% control of the pest at different trials conducted at Tocklai Experimental Tea Estate (Tables 6.10-6.13). On the same trials conventional pesticides, namely Oberon 240 SC @ 300 ml and 400 ml/ha, Applaud 25 SC @ 300 and 600 ml/ha; Fenpyroximate 5% @ 300 and 600 ml/ha, Fenpropathrin 3% @ 250 and 300 ml/ha, Meothrin 30% @ 50, 75 and 100 g a.i./ha and Danitol 10 EC @ 1:1000 and 750 and 500 ml/ha gave 76-93% control as compared to 84-92% control obtained from the standard Ethion and Dicofol formulations.

Thrips : One field trial was conducted at Borbhetta Exptl. Estate using Numethrin 10% EC @ 1:2000, Nurocombi 240 SC @ 1:1000, Gem 10 EC @ 1:2000, Kungfu 2.5 EC @ 1:1000 and 1:2000, Bulldock 0.25 SC @ 1:1000 and 1:2000, Regent 5 SC @ 1:1600, 1:800 and 1:500, Civet 32.8 EC @ 1:500 and 1:400. Results are given in Table 6.14. All the pesticides under trial were found effective with a range of control from 74 to94%. The standard Endosulfan 35 EC @ 1:400 gave 86% control.

Helopeltis : Two field trials were conducted at Tocklai and Borbhetta Experimental Estates using Kritap 50 SP @ 1:1000, Fast 50 SP @ 1:1000, Punkaso 10 EC @ 1:1000, Tatamida 17.8 EC @ 1:3000, Numethrin 10 EC @ 1:2000, Lucid 75 SP @ 1:400, Nurocombi @ 1:1000, Sherpa-alfa 10 EC @ 1:2000, Kungfu 2.5 EC @ 1:1000 and 1:2000, Bulldock 25 EC @ 1:1000 and 1:2000, Actara 25 WG @ 1:8000 and 1:4000, Regent 5 SC @ 1:1600, 1:800 and 1:500 and Civet @ 1:500 and 1:400. All the pesticides were found effective at all the dosages giving 70-92% control except Regent @ 1:1600, which registered only 47.4% control of the pest (Tables 6.15 and 6.16).

Looper : Bioefficacy of Bulldock 0.25 SC @ 1:1000 and 1:2000, Sherpa-alfa 10 EC @ 1:4000, Regent 5 SC @ 1:800, Danitol 10 EC @ 1:400, Kungfu 2.5 EC @ 1:1000 and 1:2000, Fast 50 SP @ 1:1000, Kritap 50 SP @ 1:1000 and Numethrin 10 EC @ 1:4000 were evaluated. Per cent control obtained ranged from 79 to 92% with different chemicals (Table 6.17).

Blister blight : One commercial field trial was conduted at Pandam T.E., Darjeeling, during August to September, 2002 to evaluate the efficacy of several chemical fungicides for controlling blister blight diseases of tea caused by *Exobasidium vexans*. Eight treatments were incorporated in the trial at different dilutions.

The treatments were imposed in randomised block designed plots with 3 replications having 15 bushes in each repeat. 4 rounds of treatments were applied at 7 days intervals immediately after a plucking round. Observations were made on the disease incidence after every plucking and the final post-treatment assessment was made after two weeks of the last round of treatment application. The observations were made by collecting 100 plucked shoots at random from each treatment to record (1) the number of infected shoots and (2) total number of blisters present on the third leaf. The results are presented in the Table 6.03.

The results presented in the table show the superior effectiveness of Hexaconazole formulations in controlling the disease by reducing upto 78.7% of infected shoots and 74.4% on number of blisters respectively. Formulations of Copper and Sulphur however showed maximum of 66.2% control of the disease. Copper oxychloride and Carboxin could also produce upto 71.2 and 66.2% control of the disease respectively.

Black rot : This trial was conducted at Diffloo T.E. in Golaghat Circle in June-July, 2002 to evaluate the efficacy of a new Hexaconazole formulation, Validamycin, an antibiotic formulation, two COC formulations and a sticker, for controlling black rot disease caused by *Corticium* species

All treatments were imposed in randomised block designed plots with 4 replications having 50 bushes per repeat. Two rounds of treatments were applied at 15 days intervals using hand operated bakpak sprayers. The final post-treatment observations were made during October, 2002 by scoring the degree of infection in each bush using 0-4 scale of severity. The results are presented in Table 6.04.

Table 6.03 Effect of chemical fungicides on the control of blister blight disease in Darjeeling

Treatment	On infected shoots		On blisters	
	Mean disease incidence	% reduction	Mean disease incidence	% reduction
Hexaconazole-I 1:1000	2.3	71.2	3.3	63.3
Hexaconazole-II 1:1000	1.7	78.7	2.3	74.4
Copper+sulfur formulation 1:400	3.0	62.5	3.7	58.9
Copper+sulfur formulation 1:200	2.7	66.2	4.0	55.5
Propineb 1:400	3.3	58.7	4.0	55.5
COC 1:400	2.3	71.2	3.0	66.7
Carboxin 1:400	2.7	66.2	3.3	63.3
Control(untreated)	8.0	-	9.0	-

Table 6.04 Effect of chemical fungicides on the control of black rot disease

Treatments	Mean disease incidence	% reduction over control
Hexaconazole 1:1000	9.25	40.3
Validamycin 1:1000	9.25	40.3
Validamycin 1:1500	7.75	50.0
COC – I 1:400	3.50	77.4
COC – II 1:400	3.00	80.6
COC+Sticker (1:400+6 ml/10 lit.)	2.25	85.4
Control (untreated)	15.50	-

The results presented in the table reveal that the standard Copper oxychloride formulation could reduce the disease upto 80.6% which increased to 86.4% when mixed with a sticker. Hexaconazole and Validamycin could provide only 40 to 50% control of the disease.

Red rust : The chemicals were evaluated for controlling the red rust disease caused by *Cephaleurous parasiticus* in a field experiment laid out at Deha T.E. in Jorhat Circle. Six treatments were imposed at different concentrations in a randomised block design with 4 replications having 50 bushes in each plot. Total four rounds of treatments were imposed during May-July, 2002, the first two rounds at 15 days interval and subsequent two rounds at monthly intervals by using hand operated bakpak sprayers.

The final post-treatment observations were made during July, 2003 by scoring the degree of infection in each bush using 1-4 scale of severity and the results are presented in Table 6.05.

The table shows that the COC formulations provided maximum control (upto 90.8%) of the disease @ 1:400 dilution. Other products, namely, Hexaconazole and Validamycin showned less effect in controlling the disease.

Table 6.05 Effect of chemical fungicides on red rust disease of tea

Treatments	Mean disease incidence	% reduction over control
Hexaconazole 1:1000	13.7	66.9
Validamycin 1:1000	21.7	47.7
Validamycin 1:1500	17.9	56.8
COC – I 1:400	7.9	80.9
COC – II 1:400	3.8	90.8
COC+Sticker (1:400+6 ml/10 lit.)	6.1	85.3
Control (untreated)	41.5	-

Advisory services

1. A new advisory service i.e. Quality analysis of the microbial biocides was initiated during the year. Under this project nine *Trichoderma* biocide samples and twelve soil samples received from different member gardens were analysed for *Trichoderma* and reported to the respective garden

2. Number of plant samples examined for pests and diseases – **58**

   Number of water samples analysed for presence of harmful bacteria = **3**

   Number of soil samples analysed for eelworm estimation = **106**

3. Special visit : The Assistant Mycologist paid a special visit to Borgang T.E. to assess their black rot problem.

Table 6.06 Results of the post treatment observations on termite control trials at Cachar (March 2000 to April 2003)

Tea Estate	Treatments	% control after		
		12 months	24 months	36 months
Jallelpore	Imidacloprid 17.8 EC @ 670 ml/ha	82.4	80.2	79.7
	Kanodane 20 EC @ 5 l/ha	82.4	78.2	76.4
	Kanodane 6.5 WP @ 6.5 kg/ha	85.0	64.0	70.5
	Endosulfan 35 EC @ 1:300	70.0	64.4	63.2
	Endosulfan+Neemazal-F @ 1:300 + 1:400	75.0	69.5	65.5
	Neemazal-F @ 1:400	50.5	59.0	58.5
Pathemara	Imidacloprid 17.8 EC @ 670 ml/ha	81.0	80.6	77.6
	Kanodane 20 EC @ 5 l/ha	88.4	75.0	74.4
	Endosulfan 35 EC @ 1:300	70.2	68.4	66.5
	Endosulfan+Neemazal-F @ 1:300 + 1:400	79.3	69.4	67.4
	Neemazal-F @ 1:400	53.1	52.5	55.0
	*Thiomethoxam 25 WP @ 500 g/ha	80.2	78.4	-

* applied on March 2001 and March 2002

Table 6.07 Results of the post treatment observations on termite control trials at Cachar (March 2000 to April 2003)

Tea Estate	Treatments	% control after		
		12 months	24 months	36 months
Koomber	Imidacloprid 17.8 EC @ 125 g ai/ha	81.0	72.2	72.4
	Kanodane 20 EC @ 5 l/ha	78.4	74.3	74.0
	Kanodane 6.5 WP @ 6.5 kg/ha	85.0	67.5	67.0
	Endosulfan 35 EC @ 1:300	75.0	53.1	54.0
	Endosulfan+Neemazal-F @ 1:300 + 1:400	56.5	50.3	54.3
	Neemazal-F @ 1:400	56.5	50.3	54.3
Rosecandy	Imidacloprid 17.8 EC @ 125 g ai/ha	80.4	66.8	70.4
	Kanodane 20 EC @ 5 l/ha	75.0	64.7	65.0
	Kanodane 6.5 WP @ 6.5 kg/ha	71.7	63.0	63.8
	Endosulfan 35 EC @ 1:300	66.7	55.5	56.0
	Endosulfan+Neemazal-F @ 1:300 + 1:400	68.7	55.6	54.6
	Neemazal-F @ 1:400	51.3	49.5	50.2
	*Thiomethoxam 25 WP @ 500 g/ha	80.5	79.2	-

* applied on March 2001 and March 2002

Table 6.08 Results of the post treatment observations on termite control trials at Durrung T.E., North Bank (March 2001 to April 2003)

Tea Estate	Treatments	% control after		
		12 months	24 months	36 months
Durrung	Imidacloprid 17.8 EC @ 500 ml/ha	77.0	78.0	75.6
	Imidacloprid 17.8 EC @ 670 ml/ha	80.2	75.5	79.2
	Kanodane 20 EC @ 5 l/ha	75.0	81.0	76.5
	Kanodane 6.5 WP @ 6.5 kg/ha	74.5	80.0	78.6
	Thiomethoxam 25 WG @ 400 g/ha	70.0	79.2	75.8
	Endosulfan+Neemazal-F @ 1:300 + 1:400	66.5	76.0	69.7
	Endosulfan 35 EC @ 1:300	63.5	75.4	68.5

Table 6.09 Results of the post treatment observations on termite control trials at Nahoroni T.E., North Bank (March 2002 to April 2003)

Tea Estate	Treatments	% control after		
		12 months	24 months	36 months
Nahoroni	Imidacloprid 17.8 EC @ 500 ml/ha	70.4	72.5	76.4
	Imidacloprid 17.8 EC @ 670 ml/ha	78.4	83.3	79.5
	Kanodane 20 EC @ 5 l/ha	70.0	81.4	77.0
	Kanodane 6.5 WP @ 6.5 kg/ha	72.4	80.4	79.8
	Thiomethoxam 25 WG @ 400 g/ha	69.5	78.0	78.2
	Endosulfan+Neemazal-F @ 1:300 + 1:400	63.5	75.0	65.4
	Endosulfan 35 EC (Standard) @ 1:300	62.5	74.4	66.2

Table 6.10 Red spider control trial at Tocklai - 2002

Treatments	Dilution	Pre treatment	1st week		2nd week		3rd week		4th week	
		Populn.	Populn.	% redn.	Populn.	% redn.	Populn.	% redn.	Populn.	% redn.
Flowable sulfur	1:200	510	238	52.3	290	43.0	141	72.3	114	77.6
Flowable sulfur	1:300	535	289	46.0	320	40.0	178	66.7	145	72.8
Micros 40%	1:200	522	251	52.0	30.2	42.1	143	72.6	104	80.0
Micros 40%	1:400	555	277	50.0	344	38.0	142	74.4	125	77.4
Sulfur (Std.)	1:200	489	272	44.3	233	52.3	117	76.0	136	72.1
Ethion (Std.)	1:400	503	266	47.1	255	49.3	45	91.0	42	91.6
Control	-	515	577	-12.0	600	-16.5	610	-18.0	629	-22.1

Table 6.11 Red spider control trial at Tocklai - 2002

Treatments	Dilution	Pre treatment	1st week		2nd week		3rd week		4th week	
		Populn.	Populn.	% redn.	Populn.	% redn.	Populn.	% redn.	Populn.	% redn.
Oberon 240 SC	300*	992	480	51.6	521	47.5	186	81.2	156	84.3
Oberon 240 SC	400*	914	465	49.1	486	46.8	165	81.9	124	86.4
Micros 40%	1:200	986	459	53.4	216	46.4	224	77.2	201	79.6
Micros 40%	1:400	1014	212	47.5	524	46.9	145	64.1	99	75.5
Applaud 25 SC	300*	404	447	55.9	480	52.7	201	80.2	124	87.7
Applaud 25 EC	600*	950	460	51.6	486	48.8	149	84.3	228	76.0
Microsul 52%	1:400	1135	472	58.4	492	56.7	264	76.7	215	81.0
Stoller 72%	1:100	1045	458	56.2	482	53.9	242	76.8	210	80.0
Stoller 72%	1:200	926	436	52.9	465	49.8	226	75.6	212	77.1
Share 40%	1:400	942	474	49.6	494	47.5	249	73.5	227	76.0
Ferproximate5%	300*	926	432	48.7	462	45.1	146	84.2	122	86.8
Fenproximate5%	600*	842	458	50.5	476	48.6	161	80.8	131	84.4
Fenproximate3%	250*	541	298	44.7	311	42.3	112	79.3	98	81.8
Fenpropathrin3%	300*	664	370	54.8	385	42.0	104	84.3	86	87.8
Ethion (Std.)	1:400	628	314	50.0	326	48.1	95	84.9	98	84.4
Sulfur (Std.)	1:400	598	297	50.3	312	47.8	145	75.8	152	74.6
Control	-	329	326	0.9	342	-3.9	342	-3.9	349	-6.0

* ml/ha

Table 6.12 Red spider control trial at Tocklai, Cinnamara 3 - 2002

Treatments	Dilution	Pre treatment	1st week		2nd week		3rd week		4th week	
		Populn.	Populn.	% redn.	Populn.	% redn.	Populn.	% redn.	Populn.	% redn.
Flowable sulfur 40%	1:200	403	194	51.8	236	41.4	120	70.2	90	77.6
-do-	1:300	380	202	46.8	229	39.7	132	65.2	106	72.1
Micros 40% SC	1:200	427	200	50.4	237	41.3	170	60.0	97	77.3
Micros 40% SC	1:400	404	193	54.8	221	48.2	125	69.0	82	79.7
Sulfur (Std.)	1:400	377	212	43.7	184	51.2	34	90.8	22	76.7
Ethion (Std.)	1:400	393	210	46.5	171	56.4	124	67.1	65	86.3
Control	-	403	419	-4.0	439	-8.9	488	-21.1	501	-22.5

Table 6.13 Red spider control trial at Borbhetta, Section No. 8/2 - 2002

Treatments	Dilution	Pre treatment	1st week		2nd week		3rd week		4th week	
		Populn.	Populn.	% redn.	Populn.	% redn.	Populn.	% redn.	Populn.	% redn.
Danitol 10 EC	1000*	1845	667	63.8	694	62.3	168	90.8	156	91.5
Danitol 10 EC	750*	1942	772	60.1	797	59.0	239	87.6	242	87.5
Danitol 10 EC	500*	1556	818	47.4	849	45.4	235	84.8	231	85.2
Meothrin 30%	100#	1921	523	67.6	701	63.5	157	91.8	149	92.2
Dicofol (Std.)	1:400	1686	812	51.8	899	46.7	206	87.8	201	88.1
Control	-	1599	1689	-5.6	1779	-11.3	1799	-12.5	1811	-13.3

* ml/h # g ai/h

Table 6.14 Thrips control trial at Borbhetta, Section No. 17 - 2002

Treatments	Dilution	Pre treatment	1st week		2nd week		3rd week		4th week	
		Populn.	Populn.	% redn.	Populn.	% redn.	Populn.	% redn.	Populn.	% redn.
Numethrin 10%EC	1:2000	167	37	77.8	44	73.6	8	86.6	6	90.0
Nurocombi	1:1000	162	75	53.7	82	49.3	9	82.6	8	84.6
Gem	1:2000	159	24	84.9	35	77.9	7	86.5	6	88.0
Kungfu	1:1000	162	22	86.4	31	80.8	6	84.6	4	92.6
Kungfu	1:2000	163	76	53.3	84	48.4	6	88.8	4	92.6
Bulldock	1:1000	159	4	97.6	11	93.0	32	79.8	24	84.9
Bulldock	1:2000	172	13	92.1	22	87.2	54	68.6	44	74.4
Regent	1:1600	165	58	64.2	66	60.0	8	86.0	7	88.1
Regent	1:800	162	50	69.0	59	63.5	4	92.0	4	92.8
Regent	1:500	162	60	63.1	65	59.8	8	86.0	6	89.4
Civet	1:500	163	52	68.0	59	63.8	5	91.0	4	92.8
Civet	1:400	163	45	72.4	54	66.8	4	92.1	3	94.1
Endosulfan(Std)	1:400	166	59	64.4	66	60.2	24	85.5	23	86.1
Control	-	159	178	-11.9	182	-14.4	187	-17.6	185	-16.3

Table 6.15 *Helopeltis* control trial at Tocklai - 2002

Treatments	Dilution	Pre treatment	1st week		2nd week		3rd week		4th week	
		Populn.	Populn.	% redn.	Populn.	% redn.	Populn.	% redn.	Populn.	% redn.
Kritap 50 SP	1:1000	74	34	54.1	41	44.6	14	81.1	14	81.8
Fast 50 SP	1:1000	63	29	53.9	33	47.6	11	82.5	10	81.0
Endosulfan 35 (Std.)	1:400	71	34	52.1	44	38.0	8	88.7	7	90.1
Control	-	71	69	2.8	74	-4.2	76	-7.0	77	-8.5

Table 6.16 *Helopeltis* control trial at Borbhetta, Section No. 23 - 2002

Treatments	Dilution	Pre treatment	1st week		2nd week		3rd week		4th week	
		Populn.	Populn.	% redn.	Populn.	% redn.	Populn.	% redn.	Populn.	% redn.
Numethrin 10%EC	1:2000	61	24	60.6	27	55.7	4	93.4	5	91.8
Lucid 75% SP	1:400	58	29	50.0	31	46.5	5	91.3	6	89.7
Nurocombi	1:1000	62	35	43.5	37	40.3	12	80.6	14	77.4
Sherpa alfa	1:2000	61	24	60.6	27	55.7	4	93.4	5	91.8
Gem (Std.)	1:2000	56	22	60.7	24	57.0	4	92.8	4	92.9
Kungfu	1:1000	55	24	56.3	25	54.5	10	81.8	11	80.0
Kungfu	1:2000	56	32	42.9	33	41.1	14	95.0	16	71.4
Bulldock	1:1000	60	28	53.3	31	48.3	4	93.3	4	93.3
Bulldock	1:2000	54	27	50.0	30	44.4	7	87.3	8	85.2
Actara 25 WG	1:8000	52	31	40.3	32	38.4	13	75.0	13	75.0
Actara 25 WG	1:4000	53	26	51.0	29	45.2	5	90.5	6	88.7
Regent 5 SC	1:1600	57	38	33.3	41	28.0	39	49.1	30	47.4
Regent 5 SC	1:800	60	33	45.0	35	41.6	15	75.0	16	73.3
Regent 5 SC	1:500	5	26	56.0	29	50.8	12	79.6	12	79.7
Civet	1:500	58	31	46.5	33	43.0	16	72.4	17	70.7
Civet	1:400	62	27	56.4	29	53.2	12	80.6	13	79.0
Control	-	58	60	-3.4	62	-6.9	64	-10.3	58	-8.6

BIOCHEMISTRY

In continuation of the project work of NMITLI and NTRF some more studies on catechin and flavour were carried out during the year 2002-03.

1. NMITLI Project

During the year tea shoots having uniform size of two leaves and a bud were collected from the extreme forms of the Assam, China and Cambod races of tea and 59 different germplasms from different tea estates, considering their agroclimatic conditions and environmental factors for estimating chemo- profile of individual catechins.

Individual components of catechins were identified and estimated by comparing with authentic standard compounds procured from sigma chemicals by using High Performance Liquid Chromatography (HPLC) with Phenomenax phenylhexyl column.

Total and individual catechins of extreme Assam, extreme China and extreme Cambod cultivars are presented in Fig. 8.01. It was observed that extreme Assam cultivars contained more than 5% of total catechins as compared to extreme China and Cambod cultivars. In all the three races the amount of epigallocatechingallate (EGCG) was highest followed by epigallocatechin (EGC), epicatechingallate (ECG), epicatechin (EC) and catechin (+ C). Among the three races Assam variety contained highest amount of total catechin (TC) followed by China and Cambod variety.

While comparing the catechin content (Figs. 8.02a – 8.02f) of the tea shoots in ten different clones collected from Upper Assam and Terai, West Bengal, it was found that catechin content in the same clone from Upper Assam was 3 - 4 % higher than that of Terai.

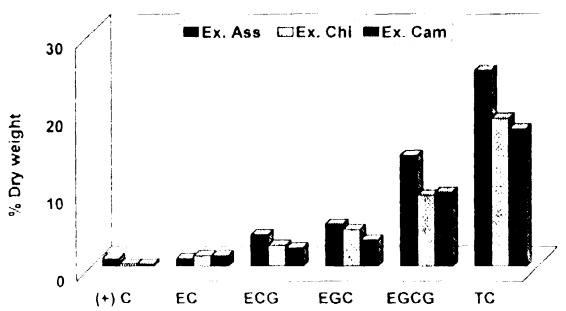

Fig. 8.01 Catechin content (%dry wt) in three extreme cultivars

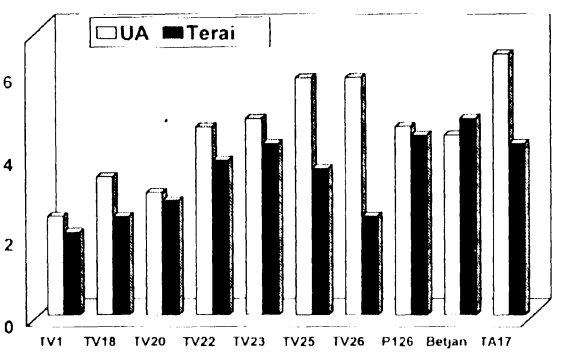

Fig. 8.02a EGC

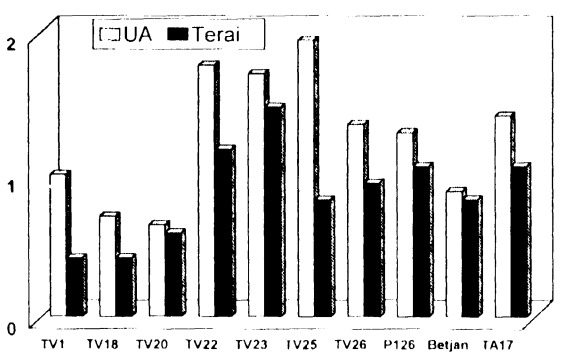

Fig. 8.02b EC

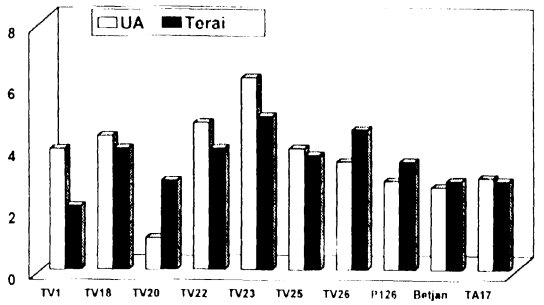

Fig. 8.02c. ECG

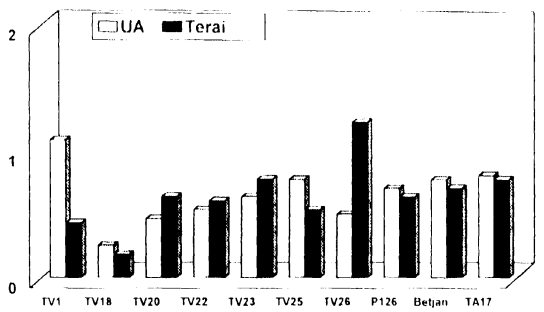

Fig. 8.02d. EGC

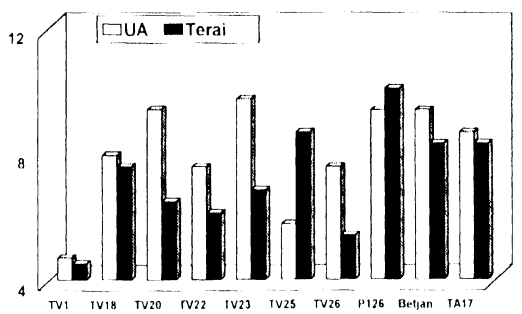

Fig. 8.02e. EGCG

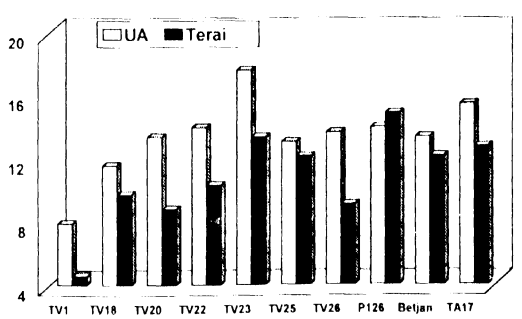

Fig. 8.02f. Total catechin

It is an interesting finding on the effect of agro-climatic conditions upon catechin biosynthesis.

The chemo-profile of catechins of 39 different Upper Assam clones is presented in Table 8.01. Well-marked variations of either total catechin or individual catechins were observed among the different clones collected from different tea estates. The total catechin contents of clones S.3A/3 (MAN), T.3E/3 (MAN), MH 4 / 16 (MAN), R94 (KOOM), S.3A/ 3 (KOOM), KOOM 23, KOOM 29, TV17 (KOOM) TV2 (KOR), T17 (KOR), TV18 (KOR), T.3E/ 3(KOR), S.3A/ 1 (KOR), TV22 (JOON), S. 3A/ 3 (JOON), TA17 (JOON), JOON 51, JOON 81, JOON 72, AZI 14, AZI 15, DJ 16 (DIN), KOR 33 (KOR) and TV18 (KOOM) were found to be significantly higher than the others. From Table1 it is found that the EGCG contents were higher in the clones T3E/3 (MAN), TV 25 (KOOM), R94 (KOOM), S.3A/3 (KOOM), KOOM 23, KOOM 29, TV 2(KOR), TV 18 (KOR), T.3E/3 (KOR), S.3A/1 (KOR), TV 9 (JOON), TA 17 (JOON), JOON 51, JOON 81, JOON 72, DJ 16 (DIN), and TV 18 (KOOM) than the others, which might affect the formation of TF and TR, and thereby the quality of tea.

The effect of shade on the synthesis of total catechins, individual catechins and phenylalanine ammonialyase (PAL) activity are presented in Fig. 8.03. It was observed that both catechin content and

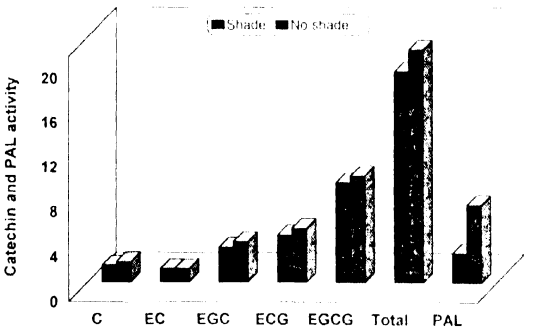

Fig. 8.03 Effect of shade on the synthesis of Catechin (%) and PAL activity (μ Kats/kg protein)

Table 8.01 Chemo-profiles of catechins of different clones collected from different tea estates of Upper Assam.

Sl No.	Sample	GA	Caff.	EGC	+C	EC	EGCG	ECG	Total catechins
1	TV29 (MAN)	ND	3.04	3.48	0.69	1.27	8.71	3.40	17.55
2	N.436 (MAN)	ND	4.07	4.57	0.57	1.11	14.36	3.62	24.23
3	S.3A/3(MAN)	0.05	4.53	7.08	0.79	1.26	13.65	3.61	26.39
4	T.3E/3(MAN)	ND	3.55	4.33	0.72	1.03	15.46	3.98	25.52
5	MH6/5(MAN)	ND	3.92	5.09	0.94	1.05	14.84	3.25	25.17
6	MH4/16(MAN)	ND	2.95	4.45	0.65	0.97	14.09	3.89	24.05
7	TV1 (KOOM)	ND	3.31	5.00	0.65	1.00	12.47	3.71	22.83
8	TV9 (KOOM)	ND	3.19	2.35	0.76	0.83	12.24	5.93	22.11
9	TV25 (KOOM)	0.09	4.24	3.71	0.58	0.50	15.58	4.52	24.89
10	R94 (KOOM)	0.06	3.42	3.96	0.72	0.90	17.32	3.44	26.34
11	TA17 (KOOM)	0.11	3.71	4.97	0.82	0.94	14.11	3.50	24.34
12	S.3A/3(KOOM)	ND	3.76	5.41	0.77	1.26	15.55	5.25	28.24
13	KOOM23	0.07	3.33	5.17	0.77	0.88	15.27	4.77	26.86
14	KOOM29	0.07	3.64	4.45	0.72	0.64	19.45	5.68	30.94
15	TV17 (KOOM)	0.07	3.49	2.69	1.48	0.92	13.75	8.06	26.90
16	TV2 (KOR)	0.06	3.82	3.96	1.03	0.79	18.13	4.62	28.53
17	TV17 (KOR)	0.11	3.34	4.47	1.03	1.80	11.18	6.60	25.08
18	TV18 (KOR)	0.06	3.80	2.92	0.47	0.54	16.74	6.58	27.25
19	P.126 (KOR)	0.08	3.51	5.34	0.82	0.99	13.48	3.50	24.13
20	T.3E/3(KOR)	0.14	3.77	5.42	0.68	1.03	15.61	4.67	27.41
21	S.3A/1(KOR)	ND	4.07	6.13	1.10	0.87	17.41	4.93	30.44
22	TV9 (JOON)	0.05	4.26	3.98	0.53	0.69	15.12	4.36	24.68
23	TV22 (JOON)	ND	3.44	4.74	0.73	1.06	14.86	5.26	26.65
24	TV26 (JOON)	0.06	4.14	4.58	ND	0.86	14.88	3.63	23.95
25	S.3A/3(JOON)	0.05	3.59	5.87	0.78	1.29	13.98	4.96	26.88
26	TA17 (JOON)	0.08	2.99	5.82	0.84	0.99	15.10	4.20	26.95
27	JOON 51	0.07	3.57	3.79	0.74	0.68	16.62	4.49	26.32
28	JOON 81	0.07	2.91	4.55	1.03	0.79	15.81	4.75	26.93
29	JOON 72	0.09	4.12	5.02	1.00	1.06	15.80	4.36	27.24
30	JOON 103	0.07	3.51	3.52	0.89	0.80	13.90	5.45	24.56
31	AZI 1	ND	3.26	6.01	0.65	0.96	13.21	3.47	24.30
32	AZI 14	ND	3.45	5.29	0.67	1.12	14.27	4.46	25.81
33	AZI15	0.05	3.70	5.32	0.70	0.83	14.37	3.89	25.11
34	DJ 16 (DIN)	0.05	3.57	4.45	0.86	1.23	16.05	4.82	27.41
35	KOR 8(KOR)	0.15	4.50	6.12	0.25	1.23	10.58	2.96	21.14
36	KOR28 (KOR)	0.13	3.67	5.09	0.58	0.85	12.13	2.69	21.34
37	KOR33 (KOR)	0.05	3.68	7.75	0.61	1.48	13.03	3.71	26.58
38	P-38 (KOR)	0.24	3.79	2.89	0.26	0.58	14.83	3.94	22.50
39	TV18 (KOOM)	0.13	3.88	3.27	0.40	0.60	16.09	5.69	26.05

GA-Gallic Acid, Caff- Caffeine,
KOOM-Koomsang, MAN-Manohari, JOON- Joonktollee, KOR- Korangani,
AZI- Azizbagh, DIN- Dinjoy.

phenylalanine ammonialyase were higher in unshaded than in shaded condition.

Phenylalanine ammonialyase is one of the key enzymes for catechin biosynthesis. The study was carried out to have a better understanding about the effect of sunlight on PAL.

NTRF PROJECT

"Extraction, Identification and Quantification of volatile flavoury constituents (VFC) in TRA released Darjeeling clones and standardization of process variables in Darjeeling tea with special reference to VFC – TRA."

As a part of our study, the black tea samples of three different cultivars were processed in different months (May to October) at Ging Tea Estate, Darjeeling.

Terpenoid contents were found to be higher in the month of May and June as compared to other parts of the season.

Tea shoots of three different popular Darjeeling cultivars were collected and manufactured in Ging tea estate, Darjeeling, twice in a month from May to October.

The aroma concentrates were prepared from 100 g black tea by steam distillation as described in our earlier report.

Comparing the retention times with authentic standard compounds procured from Sigma chemicals identified individual components. Similar Gas Chromatographic conditions were maintained as described in our report of 2001-02.

The amount of each component is determined and expressed as the ratio of each peak area to that of internal standard in the chromatogram.

Seasonal variations of 14 major volatile flavoury compounds in three different cultivars are shown in Tables 8.02, 8.03 and 8.04 and Figs. 8.04-8.08. Terpenoid compounds specifically linalool, linalool oxides and geraniol are usually higher in the months of May and June compared to July to September.

Lipid and fatty acid degrading volatiles were generally higher in the months of July and August compared to May, Sept. and October.

Among the other components Benzyl alcohol was found to be higher in the months of July and August than at other parts of the season. However, ß- ionone having fruity flavour was the highest in the month of May followed by June and lowest in the month of July.

Table 8.02 Seasonal variation of some volatile flavoury constituents in Darjeeling tea (cultivar 1)

Flavour	May	June	July	August	Sept.	Oct.
n- hexanol	1.20	1.07	2.50	2.56	2.07	1.98
Phenylaceteldehyde	1.86	2.26	0.85	0.76	1.88	1.60
Methylsalicylate	0.07	1.21	0.04	0.06	0.07	1.02
Benzylalcohol	4.51	4.22	6.000	6.03	5.55	4.73
Phenyl- ethanol	2.60	3.00	1.20	1.09	2.30	2.06
ß- ionone	4.40	3.82	2.80	3.01	2.96	3.23
Nerolidol	2.30	2.76	1.10	1.25	1.07	2.05
Bezaldehyde	1.00	0.08	1.56	1.13	1.07	1.16
Pentenol	0.80	0.37	1.70	2.01	1.62	0.98

Table 8.03 Seasonal variation of some volatile flavoury constituents in Darjeeling tea (cultivar- 2)

Flavour	May	June	July	August	Sept.	Oct.
n- hexanol	1.74	1.09	3.19	2.96	1.95	2.00
Phenylaceteldehyde	1.52	2.11	1.44	0.98	2.09	2.06
Methylsalicylate	1.63	1.37	0.97	0.92	0.49	1.80
Benzylalcohol	3.90	4.19	8.56	7.67	6.00	4.24
Phenyl- ethanol	3.44	2.87	0.07	0.06	1.52	2.06
ß- ionone	6.12	6.15	3.21	2.29	3.21	4.42
Nerolidol	3.01	3.01	1.16	2.06	1.77	2.80
Bezaldehyde	0.06	0.11	1.75	1.73	1.07	1.11
Pentenol	1.46	0.91	2.49	2.02	1.96	1.00

Table 8.04 Seasonal variation of some volatile flavoury constituents in Darjeeling tea (cultivar 3)

Flavour	May	June	July	August	Sept.	Oct.
n- hexanol	2.35	2.00	4.86	3.97	3.05	2.12
Phenylaceteldehyde	2.00	2.51	1.83	0.96	0.99	2.12
Methylsalicylate	1.11	2.06	1.43	0.94	1.77	1.07
Benzylalcohol	4.07	3.00	7.68	7.99	4.06	5.00
Phenyl- ethanol	3.97	4.05	1.69	0.08	2.29	2.22
ß- ionone	7.09	5.22	2.01	3.66	3.56	4.12
Nerolidol	2.66	3.56	1.00	2.18	1.97	2.16
Bezaldehyde	1.16	0.96	2.01	2.29	1.43	0.88
Pentenol	1.12	1.36	3.42	3.42	0.98	1.39

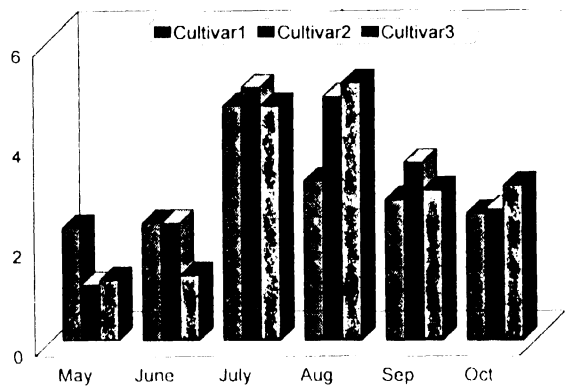

Fig. 8.04 Cis-3-hexenol

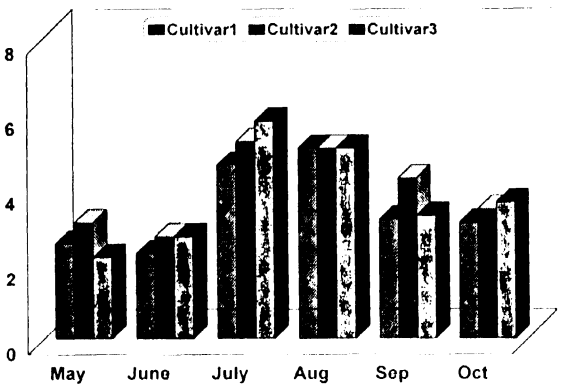

Fig. 8.05 Trans-2-hexenal

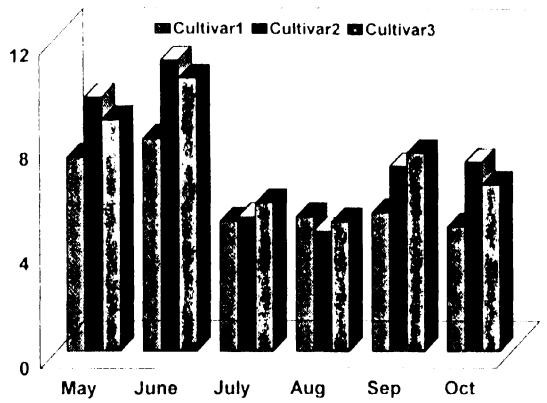

Fig. 8.06 Linalool

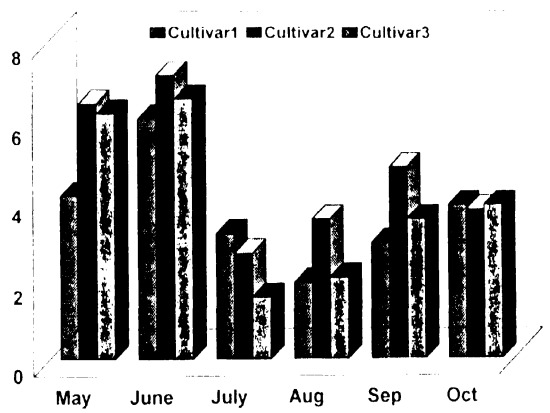

Fig. 8.07 Geraniol

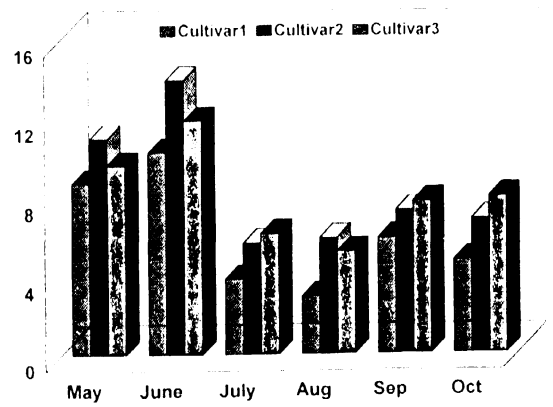

Fig. 8.08 Linalool oxide

Research Approach

In addition to the above the following studies on enzyme activity were carried out:

(a) Gel electrophoresis was carried out for iso-enzyme separation.

(b) Glycosidase, Polyphenol oxidase and Peroxidase activities were measured in different cultivars.

Service rendered

During this period 637 black tea samples were received from different departments of Tocklai and commercial tea gardens. These samples were analyzed for various biochemical parameters such as caffeine, theaflavins, thearubigins, water-soluble contents, pH, moisture etc in relation to quality. Twelve water samples received from commercial tea gardens were analyzed for their suitability for use in tea factory.

STATISTICS AND AGRI. ECONOMICS

Service: Computer Application

An effort was made to develop an indigenous user-friendly computer software, using existing resources, to replace the existing manual card recording system of periodicals in Tocklai library. The manual record keeping system uses a number of cards for a particular journal or periodical subscribed continuously from year to year. For libraries which subscribe large number of journals and periodicals over a long period of time it often becomes difficult to manage manually the increasing number of cards. This is the main reason for the use of computer in replacement of the old system of cards to:

1. View the availability of a particular periodical.
2. View the availability of a desired volume/issue in a periodical

The software was developed in Microsoft Access 2000. The holdings database has the following fields to accommodate the card information for each periodical:

1. Title of the periodicals
2. Publisher's name and address
3. Number of issues per year / volume
4. Volumes of the journals received and the corresponding year.
5. Incomplete issue(s) in each volume, if any.
6. Missing volumes, if any.
7. Subscription status whether Continued/ discontinued
8. Language, if not in English.

During the year only 434 periodicals with the records spread over 635 cards were incorporated in the database. The success of the system depends on:

1. Complete computerization of existing cards.
2. Adding record to the database on arrival of new periodicals.
3. Updating necessary database fields on arrival of fresh issue(s) of the existing periodicals.

Methodology of Experimentation.

Statistical design, block layout and treatment randomization plan were suggested to two proposed new trials.

Routine Work: Data Processing

The following data were processed in computer:

1. Statistical analysis of data from on-going field / laboratory trials of different departments of Tocklai and Outstations : Analyses were done for individual as well as for combined years. The departmentwise break-up of statistical analyses carried out during the year was as follows:

Department	Annual no. of trials	Combined over years
Advisory	36	
Agronomy	70	1
Plant physiology	27	5
Total	**133**	**6**

2. Staff salary for Tocklai and Outstations for 2002-03, preparation of relevant statements, calculation of arrears and estimated staff salary budget for 2003-2004 etc.
3. Labour wages for Tocklai and Borbhetta experimental estates including ration, bonus, leave wages etc.
4. Miscellaneous jobs.

TEA PROCESSING & MANUFACTURING ADVISORY

Modified Conventional Rolling Table

Process was initiated for commercialization of the technology of Modified Rolling Table by associating a machinery manufacturer as "Associated Developer". Accordingly, M/s Sardar Karnail Singh & Sons of Dibrugarh, a reputed Rolling Table manufacturer, was selected and MOU was signed and the technology was transferred to the firm for commercial exploitations.

Electronic Monitoring and Control System for Withering :

Installation and commissioning of another five units at 1) Azizbag TE, 2) Bagrodia TE, 3) Batelli TE, 4) Joonktolee TE and 5) Tengpani TE were completed during the year. The units would be put under commercial use during this season. Our Associate Developer received enquiries from overseas also for the system, during the year. Steps are being taken for patenting the system within the country and abroad.

Collaborative Projects with CMERI, Durgapur

The following five collaborative projects were taken up with CMERI, Durgapur:

1) Fluffing of leaf in withering troughs – for uniform spreading of leaf.
2) Uniform feeding of leaf to Rotorvane – work done by Tata Tea on this subject were reviewed and taken into consideration for this project.
3) Sharpening of CTC rollers in pair.
4) Microwave drying of Tea – feasibility study.
5) Alternative method of leaf maceration to replace CTC machine.

Design of the machines proposed by CMERI under guidance from TRA was frozen. Attempts are, being made to involve Associated Developers for development of the prototypes for the following machines :

1) Fluffing of leaf in withering troughs
2) Uniform feeding of leaf to Rotorvane

M/s Vikram India, an Associated Developer, was handed over the responsibility for further development and commercialization of the machine for sharpening of CTC rollers in pair.

As regards microwave drying, attempts are being made to communicate with SAMEER – a sister concern of CDAC, Kolkata, on the scope of using radio frequency wave in tea drying. Radio frequency has been successfully used for drying of several food products.

Prototype of a machine, based on micronizer concept, was put under initial trial as an alternative to RV/CTC. While the prototype could macerate the leaves to the desired level, it did suffer from excessive fly-off at the discharge end, high power requirement and low output. The prototype was shifted to TRA Nagrakata Sub-station and thereafter to Hope T.E. for extensive trials. However, the trials conducted, did not improve the capacity of the machine. Possibilities of reengineering the machine to minimize the shortfalls and incorporate the desired features are being looked into.

State of the Art Factory at Tocklai

A proposal with project outlay of Rs. 132 lakh was put up to Govt. of India, through the Tea Board, for

establishing a state-of-the-art pilot-processing factory with capacity of 50 kg/hr at Tocklai under the Tea Automation Project. The proposal was approved by the Tea Board. The project is being funded jointly by the Ministry of Information Technology (MIT), Tea Board and the Council for Scientific and Industrial Research (CSIR) and TRA's partners in this collaborative venture would be CEERI, Pilani and CDAC, Kolkata. Site for the factory was selected at the location of the erstwhile Ross Institute building, which housed the present Statistics and the Medical departments. These departments were shifted to new location and the old building was demolished.

Initial plan for the envisaged factory with RCC structure was revised because of economic consideration and new design of the building (208ft.x 40ft.) with tubular structures was finalized. The construction of the building was due to start in April, 2003.

List of machinery including their specifications was sent to the machinery manufacturers for submission of their quotations. Based upon the recommendation of the tender committee constituted for the purpose, suppliers of the machinery were finalized and orders were placed.

Environment Controlled Manufacturing (ECM) Unit was procured under the Tea Automation Project and was temporarily installed at the Biochemistry department. It is expected that this equipment would help in getting an insight into the precisions necessary in tea processing conditions, which could not be tackled so far, as all the experiments conducted were under ambient conditions, which varied from time to time. Experiments were being planned to be conducted during the next year.

Tea Packaging and Storage Experiment (Alternative Packaging Material)

As a part of the project work on alternative packaging material, organoleptic assessment and Biochemical analyses of tea packed HDPE sacks showed no significant differences when compared with jute bags. However, quality of the stored tea was found to gradually deteriorate in both HDPE and jute bags after three months of storage.

Post Harvest Handling of Tea

Trials were conducted to assess deterioration in quality due to faulty handling of plucked leaf in commercial gardens. Results showed that increase in temperature and percent damage of leaf depended upon the time taken for transportation and packing density of the leaf. Temperature above 40°C was found to affect adversely the quality attributes of chemical constituents. Increase in the leaf damage percentage also had harmful effect on overall cup quality.

Service to the other Departments :

Necessary help was extended to other departments of Tocklai by manufacturing and evaluating tea samples drawn from field and factory trials

a) Selection of clones and bielonal stocks by the Botany department.

b) Trials with regard to tainting of tea by spraying of various chemicals conducted by Plant Protection department.

c) Plucking, pruning/skiffing and manuring experiments conducted by the Agronomy department.

d) Experiments by the Biochemistry department on biochemical characterization of clones.

Tea Tasting

During the year 6,790 tea samples were tasted and evaluated by the Tea Taster.

NAGRAKATA SUB STATION

1. GENERAL

Dr. M. Goswami, Asstt. Advisory Officer joined the Sub Station on 10.1.2003 on transfer from Tocklai.

Dr. U. Barua, Sr. Scientific Assistant was transferred to Tocklai in 2002.

2. Advisory services

a) Visits

Region	No. of member estates	No. of estates visited	No. of advisory visits
Dooars (including Goalpara)	156	129	280
Terai	58	42	108
Darjeeling	70	69	116

b) Training courses

i) A series of workshop on Pruning and Cold Weather Practices were organised in different regions between 23.11.2002 and 26.11.2002 as detailed below :

Region	Date	Venue (T.E.)	No. of participants
Dooars	23.11.2002	Bhogotpore	90
Terai	25.11.2002	Kamalpur	61
Darjeeling	26.11.2002	Sungma	111

ii) Workshop on Water Management in Tea with Special Reference to Irrigation for Dooars and Terai was held on 11.02.2003 at Nagrakata - 49 executives from various estates participated.

c) Training cum demonstration programme at grass root level/employees

Several training cum demonstration programmes for grass root level employees of the estates on tipping/ plucking, spraying technique, bringing up of young tea and vegetative propagation were organised at different venues during the year. The numbers of participants in different areas were as follows :

Region	No. of demons-trations	No. of gardens	No. of participants
Dooars	6	17	230
Terai	4	15	196
Darjeeling	1	6	24

d) Meetings and seminars

i) Area Scientific Committee seminars on Agriculture

Date	Region	No. of participants
23.05.2002	Dooars	79
22.05.2002	Terai	58

ASC seminar in Darjeeling could not be organised in the year due to some technical problem.

ii) North Bengal Committee meeting on 18.12.2002.

iii) The Chairman and Vice-Chairman visited Dooars, Terai and Darjeeling between 17.12.2002 and 19.12.2002 and interacted with industry representatives.

e) Soil analysis

Region	No. of samples	No. of estimations
Dooars	1975	5920
Terai	1200	2948
Darjeeling	394	2263

In addition 101 soil samples from all the three regions were analysed for eelworm estimation. Out of these only 3 samples were found to be unsuitable.

f) Agrochemical testing

Bioefficacy test of different agro-chemicals (pesticides/herbicides) received from member estates were carried out and compared against standard. A total of 81 tests were done at TRA, Nagrakata. One samples was found to be substandard.

Dooars	38
Terai	34
Darjeeling	9

g) Pest and disease identification

56 samples of pests and diseases received from member estates were identified and reported.

h) Green leaf/cuttings distribution

47723 kg of green leaf was produced at the Head Quarter plot of Nagrakata and sold to Nyasylee Tea Estate. No cutting was available for sale as the Head Quarter plot was lashed out by severe hail storm in May 2002.

FIELD MANAGEMENT PRACTICE

Pruning : In the Dooars and Terai regions, most of the estates followed a pruning cycle of 3-4 years duration. The pruning cycle followed for the youngish mature tea was LP-UP-UP and that for mature teas was LP-UP-DS/MS-UP. The member estates were enlightened about the standard of pruning and improvement of bush sanitation through workshop.

Plucking : The standard of plucking was improved reasonably as many estates resorted to 7/8 days plucking round. However, it will take time to change the habit of the workers as they are accustomed to coarse plucking.

Pests : Mild to moderate incidence of mites, *Helopeltis*, looper and red slug caterpillars were reported from the Dooars, Terai and Darjeeling. Infestations of *Thrips* remained mild in the Dooars but *jassids* was found to be of severe magnitude in some estates. Due to slump in the economy, the hard pesticides were found to constitute a large part of spraying schedule.

REGIONAL FIELD EXPERIEMNTS

The list of ongoing experiments in Terai and Darjeeling are given in Appendix I. The field experiments in the Dooars region had to be discontinued from beginning of 2002 under unavoidable circumstances. Summary of some important experiments are presented below :

Terai region

1. Organic Vs inorganic nitrogen manuring

The experiment was being conducted at Kiranchandra Tea Estate on a youngish mature stand of clonal tea (TV26) to find out the efficiency of nitrogen supplemented by organic and inorganic sources or in combination of both on yield of tea. Phosphate and potash were applied at uniform rate of 50 kg P_2O_5/ha and 150 kg K_2O/ha in all the treatments. The results for the period 1999-02 are presented in Table 12.01.

During the year 2002, the bushes received light pruning, as in the past. Total withdrawal of nitrogen (T16) significantly depressed yields except for

Table 12.01 Response to organic and inorganic sources of nitrogen

	Treatments	Yield (KMTH) 1999 (UP)	2000 (DS)	2001 (UP)	2002 (LP)
T1	Celrich at 17.5 mt/ha equivalent to 120 kg N/ha (N1)	3596	2389	1991	1561
T2	Celrich at 21.8 mt/ha equivalent to 150 kg N/ha (N2)	3568	2283	1833	1547
T3	Celrich at 26.2 mt/ha equivalent to 180 kg N/ha (N3)	3565	2401	2295	1608
T4	Urea at 120 kg N/ha (N1)	4412	2687	2961	1965
T5	Urea at 150 kg N/ha (N2)	4448	2711	2973	2118
T6	Urea at 180 kg N/ha (N3)	4656	2669	2996	2128
T7	Celrich (N1-50%) + Urea (N1-50%)	4102	2429	2305	1880
T8	Celrich (N1-25%) + Urea (N1-75%)	3946	2349	2396	1879
T9	Celrich (N1-75%) + Urea (N1-25%)	3715	2514	2588	1815
T10	Celrich (N2-50%) + Urea (N2-50%)	4095	2540	2240	1666
T11	Celrich (N2-25%) + Urea (N2-75%)	4452	2761	2925	2078
T12	Celrich (N2-75%) + Urea (N2-25%)	3631	2310	2659	1861
T13	Celrich (N3-50%) + Urea)N3-50%)	4138	2545	2569	1791
T14	Celrich (N3-25%) + Urea (N3-75%)	4340	2727	2740	1991
T15	Celrich (N3-75%) + Urea (N3-25%)	4292	2594	2505	1929
T16	Control (No fertilizer)	3469	1964	1826	1541
CD at 5%		535.5	266.2	463.1	315.9
CV%		7.98	6.41	11.17	10.33

treatment where nitrogen was completely supplemented by organic source. Nitrogen supplemented by inorganic source produced significantly higher yields at all levels over cotnrol or organic sources and there was no difference within different levels of inorganic nitrogen. Organic and inorganic combination of N 150 (25:75, T11) and N180 (75:25, T14) produced significantly higher yields over N150 (50:50, T10).

Results for the period 1999-02 show that total supplementation of nitrogen by organic form failed to sustain productivity in all these years as compared to inorganic source. There was hardly any difference in yield between total withdrawal of nitrogen and nitrogen supplemented by organic source in these years except for the year 2000.

2. Methods of bringing up of young tea (spring planted) D/131

As already reported in Ann. Sci. Rep. 2001-02, the trial was laid in the year 1999 at Pahargoomiah T.E. to study the effect of different methods of bringing up of young tea (spring planting) on growth and productivity. The treatment details as well as result for the period 1999-02 are presented in Table 12.02.

The results suggest that frame formation pruning, after keeping the teas unpruned for a year, tended to support higher productivity in the pruned year (T1, 2001), which was significantly higher than T2 (FFP2). During year 2002, significantly higher yield was recorded under treatment T4 as compared to T1 and T3 when both these treatments were also

Table 12.02 Effect of different methods of bringing up of young tea on yield (KMTH)

Treatment	Year			
	1999	2000	2001	2002
T1	532 (Decenter at 30 cm, tip at 60 cm)	2238 (Unprune, pluck to janam)	1649 (FFP1 at 35 cm, tip at 60 cm)	2742 (Unprune, pluck to janam)
T2	397 (Decenter at 20 cm, tip at 75 cm)	776 (FFP1 at 40 cm, tip at 65 cm)	2675 (Unprune, pluck to janam)	1014 (FFP2 at 45 cm, tip 75 cm)
T3	378 (Decenter at 20 cm, tip at 75 cm)	847 (FFP1 at 40 cm, tip at 75 cm)	847 (FFP2 at 45 cm tip at 75 cm)	2933 (Unprune, pluck to janam)
T4	362 (Decenter at 20 cm, tip at 75 cm)	808 (FFP1 at 40 cm, tip at 75 cm)	2755 (Unprune, pluck to janam)	3222 (Unprune, pluck to janam)
CD at 5%	-	270	254	261
CV%	-	16.79	8.39	7.63

unpruned. Through the period 1999-02, the total production under T4 was considerably higher (+43%) than average of rest of the treatments (not above T1).

Darjeeling region

1. Organic Vs inorganic nitrogen manuring

The experiment was initiated in the year 1999 at Sungma T.E. in an old (1864) China hybrid tea. The teas received medium pruning in the year 2000 and during 2002, the teas after keeping unprune till July were deep skiffed. Nitrogen was applied at 60 kg, 90 kg and 120 kg N/ha in the inorganic treatments in the form of urea and at 40 kg and 90 kg N/ha in organic treatments in the forms of vermicompost, castor oil cake and cowdung. Phosphate was applied at an uniform rate of 20 kg P_2O_5/ha (as rock phosphate) in all treatments, while potash was applied only under inorganic nitrogen treatments at 35 kg, 50 kg and 70 kg K_2O/ha (as MOP), respectively, with 60 kg, 90 kg and 120 kg N treatments.

The treatmentwise yield data for the period 2000-2002 are presented in Table 12.03.

In the first year of experimentation (2000) inorganic nitrogen at 60 kg N/ha produced significantly higher yields over control (T10) as well as T5 (Vermicompost at 90 kg N/ha) and T8 (Cowdung at 40 kg N/ha). Higher level of inorganic nitrogen failed to produce any crop gain. In 2001, inorganic nitrogen at 120 kg N/ha produced significantly higher yields over T2 (inorganic nitrogen at 90 kg N/ha), T5 (Vermicompost 90 kg N/ha), T8 (Cowdung at 40 kg N/ha) and control. Castor oil cake at 40 kg N/ha (T6) also produced significantly higher yield over T5 (Vermicompost at 90 kg N/ha) and control.

Table 12.03 Response to organic and inorganic sources of nitrogen

Treatments (N:P:K)	Yield (KMTH) 2000 (LP)	2001 (UP)	2002 (UP)
T1 Inorganic fertilizer (60:20:35)	232	735	506
T2 Inorganic fertilizer (90:20:50)	178	650	544
T3 Inorganic fertilizer (120:20:70)	205	816	581
T4 Vermicompost (40:20:0)	182	686	540
T5 Vermicompost (90:20:0)	167	593	562
T6 Castor oil cake (40:20:0)	202	792	572
T7 Castor oil cake (90:20:0)	188	760	563
T8 Cowdung (40:20:0)	155	659	584
T9 Cowdung (90:20:0)	196	742	585
T10Control (No manure)	162	626	479
CD at 5%	62	148	49
CV%	19.47	12.21	5.18

During 2002, except for T1 (inorganic nitrogen at 60 kg/ha) all other treatments produced significantly higher yields over control. T1 also produced significantly lower yields over all other treatments except for T2 (inorganic nitrogen at 90 kg N/ha) and T4 (Vermicompost at 40 kg N/ha).

The results from initial three years of experimentation suggest that under Darjeeling conditions no appreciable differenc on yield sustainance may be expected between organic and inorganic sources of nitrogen. However, withdrawal of potash under organic treatment might affect productivity on the long run.

2. Effect of foliar application of Pronto and Perfectose on yield of tea (Dj-78)

The experiment was laid out in the year 2000 at Bannockburn T.E. on an old Chinary seed jat to compare the efficiency of two commercial growth promoting formulations 'Pronto' and 'Perfectose'. Both these formulatios were applied 1 ml per litre of water and 2 ml/l as foliar spray and compared against water spray as well as standard sprays of urea and zinc sulphate. In one set of treatments only two rounds of spraying was done i.e. at the end of first flush and at the end of rain flush. In the second set of treatments four spraying i.e. beginning of first flush, end of first flush, end of 2nd flush and end of rain flush were done. The conventional urea + zinc spraying was applied thrice i.e. end of first flush, 2nd flush and rains flush. The results for 2001 and 2002 are presented in Table 12.04.

During the first year of experimentation foliar spraying of urea and zinc sulphate produced

Table 12.04 Effect of foliar application of Pronto and Perfectose on yield of tea

Treatments	Mean yield (KMTH) 2001 (UP)	2002 (UP)
T1 Control (Water spray)	300	479
T2 Pronto 1 ml/l water (2 sprays)	294	529
T3 Pronto 2 ml/l water (2 sprays)	266	541
T4 Pronto 1 ml/l water (4 sprays)	255	583
T5 Pronto 2 ml/l water (4 sprays)	246	577
T6 Perfectose 1 ml/l water (2 sprays)	281	518
T7 Perfectose 2 ml/l water (2 sprays)	302	622
T8 Perfectose 1 ml/l water (4 sprays)	288	514
T9 Perfectose 2 ml/l water (4 sprays)	299	569
T10 Urea (1%) + zinc sulphate (1%)(3 sprays)	319	526
CD at 5%	68	67
CV%	13.97	7.19

significantly higher yield over foliar application of Pronto @ 2 ml/l for four rounds (T5). However, there was no difference between rest of the treatments. In the second year when the teas were kept unpruned, foliar spraying of Perfectose @ 2 ml/l for two rounds (T7) produced significantly higher yields over control as well as zinc and urea spraying. During both these years Perfectose applied at 2 ml/l for two rounds tended to produce higher yields over rest of the treatments. No qualitative enhancement could be noted due to treatments.

3. Bringing up of young tea

The experiment was initiated in the year 1998 at Sungma T.E. on a clonal section (Teesta Valley 1) planted in September 1998 to test four different methods of bringing up of young tea. During the '0' year (1999) the teas were debudded above 20 cm from ground as and when ready. During the +1 year (2000), the teas were decentered at 20 cm during February, March and subsequently tipped between 60cm and 75 cm under different treatments. In the +2 year (2001) except for one treatment which was kept unpruned all other treatments received the first formative pruning at 40 cm above ground during end February and were tipped between 65 cm and 75 cm. In the +3 year (2002), one treatment received the first formative pruning at 45 cm during end February. The teas were fertilized with 10:5:10 YTD @ 10 g/plant during '0' year and at 1000 kg/ha, 1400 kg/ha and 1500 kg/ha during +1 year, +2 year and +3 year, respectively. Other cultural practices remained same for all treatments.

The treatment details and results for the period 1999 to 2002 are presented in Table 12.05

Table 12.05 Effect of different methods of bringing up of young tea

Treat-ment	Yield (KMTH)			
	0 1999	+1 2000	+2 2001	+3 2002
T1	Plant tea, debudded when ready above 20 cm	Decentering at 15-20 cm. Tip at 60 cm. (100 kg YTD/ha)	Selective heading back between 20-25 cm. Pluck to janam at 60 cm (1400 kg YTD/ha)	Unpruned. Pluck to janam (1500 kg YTD/ha)
T2	Plant tea, dubudded when ready above 20 cm	Decentering at 15-20 cm. Tip at 65 cm. (1000 kg YTD/ha)	Selective heading back between 20-25 cm. Pluck to janam at 65 cm (1400 kg YTD/ha)	FFP at 30-35 cm. Tip at 65 cm (1500 kg YTD/ha)
T3	Plant tea, debudded when ready above 20 cm	Decentering at 15-20 cm. Tip at 70 cm. (1000 kg YTD/ha)	Selective heading back between 20-25 cm. Pluck to janam at 70 cm (1400 kg YTD/ha)	FFP at 30-35 cm. Tip at 70 cm. (1500 kg YTD/ha)
T4	Plant tea, debudded when ready above 20 cm	Decentering at 15-20 cm. Tip at 75 cm.. (1000 kg YTD/ha)	Selective heading back between 20-25 cm. Pluck to janam at 75 cm (1400 kg YTD/ha)	FFP at 30-35 cm. Tip at 75 cm (1500 kg YTD/ha)

There was no significant difference in yield amongst treatments in all the years

PLANT PROTECTION

Studies on pest-predator-parasite dynamics in North Bengal Tea Estates

Survey on natural enemies of tea pests was initiated from December 2002 with the help of D-Vac machine to study their seasonal occurrence under the different agro-climatic conditions in Dooars, Terai and Darjeeling. In the district of Darjeeling two organic gardens were also selected to compare the incidence pattern of natural enemies with conventional gardens.

Population of natural enemies in the gardens of Darjeeling district was found more than that in the gardens of Dooars and Terai. Average population of natural enemies was found to be on higher side in organic than in conventional gardens of Darjeeling district. Maximum number of predators and parasites were found during the months of January and February in Dooars and Terai when pesticide application was minimum. In conventional gardens of Darjeeling district natural enemies were found to increase from March onward (Table 12.06).

Among the predators, lady bird beetles were found to be maximum. Lady bird beetles were more in Mohorgong Gulma T.E. and spiders were maximum in Manabari T.E.

Among the parasitoids *Braconids* were found to be maximum. *Braconids* were more in Satali T.E. Lowest number of *Braconids* were found in Hansqua T.E. (Terai).

Among all the estates, all types of natural enemies were found (Table 12.07) in Satali and Soongachi T.Es in Dooars. Both are conventional estates.

The work was being continued and the collected samples were being sent to different institutes for identification.

Table 12.06 Population of predators (a) and parasitoids (b)

Name of garden	December		January				February				March			
	2nd fortnight		1st fortnight		2nd fortnight		1st fortnight		2nd fortnight		1st fortnight		2nd fortnight	
	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
Satali	40	57	34	9	54	17	23	11	36	14	16	2	21	1
Birpara	4	16	6	2	9	3	18	6	10	5	21	10	20	4
Lakhipara	2	5	8	2	14	3	33	7	29	1	45	10	29	9
Grassmore	8	36	25	17	35	23	38	9	114	6	16	8	30	2
Soongachi	8	14	37	11	22	20	35	24	31	5	38	8	21	3
Manabari	11	5	15	4	48	9	38	9	114	6	16	8	30	2
Mohorgung Gulma	17	17	26	28	322	9	1942	49	669	11	233	0	108	3
Hansqua	7	4	4	11	18	1	56	13	40	2	190	0	84	4
Makaibari	32	14	32	12	44	18	100	9	81	5	35	14	81	2
Castleton	38	13	18	8	25	4	26	4	49	3	17	13	192	8
Pussimbing	13	51	14	35	12	5	11	11	13	14	17	30	25	8
Glenburn	-	-	-	-	-	-	-	-	28	20	29	10	25	5
Namring	9	21	34	15	15	0	10	5	19	3	16	5	13	4

Table 12.07 Types of predators and parasitoids collected

	Predators						Parasites					
Tea Estates	a	b	c	d	e	f	g	h	i	j	k	l
Satali	81	14	8	5	3	112	1	1	10	77	4	-
Birpara	17	4	12	5	1	65	1	0	11	29	2	-
Lakhipara	97	6	1	2	0	89	0	0	6	28	5	0
Grassmore	167	5	6	13	3	109	0	0	17	45	9	3
Soongachi	71	2	11	23	1	106	3	1	32	37	6	2
Manabari	83	2	8	7	4	208	0	1	11	28	9	0
Mohorgung	3219	4	7	3	3	154	0	2	32	24	49	6
Gulma												
Hansqua	274	5	53	4	0	99	0	0	13	14	2	1
Makaibari	174	5	12	98	0	141	1	2	30	38	0	0
Castleton	296	1	52	24	2	107	3	12	10	40	8	0
Pussimbing	55	13	6	28	0	48	0	2	62	62	4	1
Glenburn	27	24	15	24	1	69	0	0	9	28	2	4
Namring	12	27	37	27	1	97	0	0	7	32	8	1

a : Lady bird
b : Preying mantis
c : Syrphid fly
d : Brown lace wing
e : Green lace wing *Chrysoperla* sp.
f : Spiders
g : Pentatomid bug
h : Geocoris bug
i : Ichneumonid
j : Braconid
k : Tachinid
l : Chalcid

SOIL

Relationship between soil oganic carbon status and other soil parameters

High soil organic carbon could be correlated with high soil acidity and high available sulphur. The relationship between these parameters is shown for the original database of 1432 soils in Fig. 12.01a and 12.01b. There is a clear increase in the frequency of highly acid soils (pH < 4, pH 4-4.5) as the organic carbon range increases and a corresponding decrease in soils of lower acidity. Ont he other hand., there is an increase in he frequency of soils with high sulphur (>60 ppm) and a corresponding decrease in soils with low available sulphur.

Relationship between soil available sulphur and available phosphate in Dooars tea soils

The inverse relationship between soil available phosphate was confirmed by data obtained through routine soil analysis of 1063 sections of Dooars, where both available sulphur and available

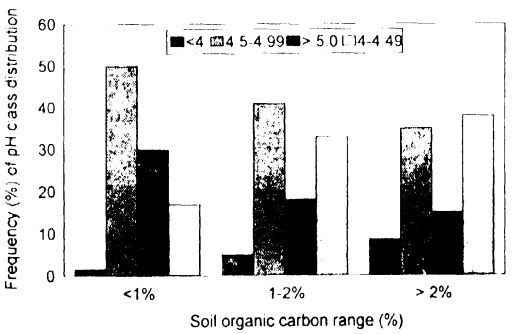

Fig. 12.01a Frequency distribution between soil organic carbon and soil acidity

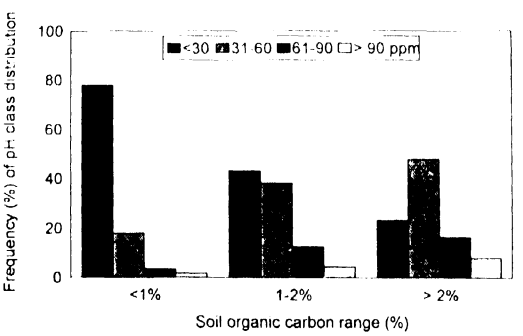

Fig. 12.01b Frequency distribution between soil organic carbon and available sulphur

phosphate were estimated. The results shown in Fig. 12.02 clearly indicate a negative relationship between available sulphur and available phosphate. While the earlier workers had developed a linear relationship between the two parameters, this work indicates that the relationship could be exponential. Experiments to study the impact of this relationship on growth of young tea was in progress.

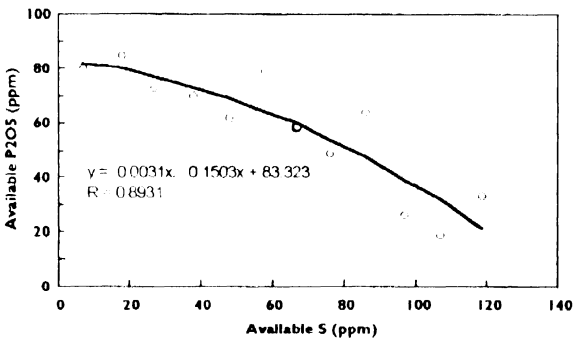

Fig. 12.02 The relationship between available sulphur and available phosphate in the tea soils of Dooars

Studies on Aerobic and Anaerobic Composting Methods

Methods of composting

The effect of aeration regime on the composition of composts after ten months of composting is shown in Table 12.08. There clearly was a loss of nutrients from the system specially under aerobic and anaerobic regimes, possibly due to leaching.

Table 12.08 Nutrient composition of composts

Methods	Aeration	pH	% LOI	% organic carbon	ppm available Potash	S	P
Heap	Aerobic	5.46	19.03	2.140	903	36	75
Heap	Semi-aerobic	6.08	8.98	5.373	2050	62	283
Pit	Anaerobic	5.63	9.77	2.930	846	29	80

Aerobic and anaerobic composts as well as raw material (stored after over drying) were compared with decomposed cattle manure. Since these composts were stored in plastic bags, leaching was limited. The results are shown in Table 12.09.

Table 12.09 Composition of aerobic and anaerobic composts compared to raw material and cattle manure

Substrate	Raw material	Cattle manure	Aerobic compost	Anaerobic compost
Moisture (%)	11.7	12.2	14.4	10.7
pH	5.7	7.3	7.9	7.8
Carbon (%)	28.6	29.4	18.4	17.2
LOI (%)	84.8	80.7	45.2	45.0
Nitrogen (%)	3.4	2.4	2.2	2.2
C:N ratio	8.4	12.2	8.5	7.8
Available K(%)	4.7	1.8	3.9	3.4
Available S(%)	0.7	0.6	0.6	0.6
Available P(%)	2.8	2.4	3.1	2.8

There appears to be little benefit of composting in terms of nutrient availability. From the organic carbon and loss on ignition data it appears that raw material applied directly to field could be more valuable than composting.

Both the raw material and cattle manure stimulated microbial activity to a greater extent than the composts. However, anaerobic compost stimulated microbial activity to a greater extent than aerobic compost, as would be expected, since anaerobic decomposition would not progress to the same extent as aerobic composting. Raw material also supported greater microbial respiration either alone or with glucose. The effect of incubation of the four sources of organic matter in soil is shown in Table 12.10. There was little effect on soil reaction and only a slight increase in the soil organic carbon. With the exception of cattle manure, all sources increased available potash, but raw material was the most effective. No. treatment had any effect on available sulphur, but raw material, cattle manure and anaerobic compost were effective in increasing

available phosphate. This suggests that raw material and cattle manure might be more effective in increasing the nutrient content of soil than either form of compost specially for a long duration perennial crop like tea, where residual effects are carried over, unlike in annual crops. A similar finding was reported by Cooper (Tocklai Memorandum 11).

Table 12.10 Effect of organic matter sources on soil nutrients

Treatment	pH	OC(%)	ppm available K_2O	S	P_2O_5
Original soil	4.60	2.699	205	10	14
Soil only	4.71	2.647	163	15	19
Soil+raw material	4.68	2.723	278	15	23
Soil+cattle manure	4.66	2.798	165	18	25
Soil+aerobic compost	4.69	2.723	233	10	10

Stability of composts in soil

Aerobic and anaerobic composts were applied to soil in the field. Microbial activity, pH, organic carbon, potash, sulphur and phosphate were estimated monthly for the treated as well untreated soil. The results show that there was little impact of either compost on the soil.

AGRO-BOTANY

In continuation of the earlier work (Ann. Sci. Rep., 2001-02), a survey was done during cold weather 2002-03, to select suitable shade tree species with short leafless period from existing stand of shade trees in different tea gardens of Dooars. After 3 years of observation 11 shade trees were short-listed which were found to have very short leafless period (Table 12.11).

Propagation

Standardization of vegetative propagation technique for stem and root cuttings of shade trees under laboratory and nursery conditions was being continued. Different growth regulating chemicals like IBA, NAA, $ZnSO_4$, 2,4-D and pH of the growing media are used in the stem and root cuttings of *A. odoratissima* and *A. lebbek*. Stem cuttings of *A. lebbek* in laboratory trial showed 30% success in the pH 5 and 6. But the root cuttings responded negatively towards the pH treatments. The vegetative growth of stem cuttings started dying after 6th weeks of initiation.

Table 12.11 Survey and selection of shade tree species with short leafless period and their propagarion

Location	Code No.	Species	Leafless period
Kumai	K_1/I/aO1	*A. odoratissima*	March
Sikarpur	S/11/AO2	-do-	Mar-Apr
Sikarpur	S/16/AO3	-do-	Feb-Mar
Amarpur	AP/S1/AO4	-do-	End Apr
Dalgaon	DG/SA13/AO8	-do-	May
Nagrakata	NK/AO9/(BB)	-do-	May
Nagrakata	NK/A10/(P.H.)	*A. lebbek*	Feb-Mar
Sikarpur/ Bhandarpur	SB/S7B/A11	-do-	Feb-Mar
-do-	SB/S9/A12	-do-	Feb-Mar
Dalgaon	DG/SA13/A15	-do-	Feb-Mar
Nagrakata	NG/S16/A16	-do-	Mar-Apr

In another trial with growth regulating chemicals like IBA, NAA, 2,4-D and $ZnSO_4$ to both stem and root cutting of *A. odoratissima* and *A. lebbek* in laboratory and pot culture trial under shade showed 30% success in shoot initiation from root cuttings with NAA application in *A. odoratissima*. No shoot initiation was observed in *A. lebbek*.

Air layering technique in young nursery plants of *A. lebbek* was being tried at two different heights (15 cm and 45 cm) from ground. After six weeks

80% of air layered nursery plants produced profuse rooting from wounded part of the plants. Shoot development was also observed within 10 days when the air layered cuttings were transferred to nursery bed under shade. The same technique was also repeated in *A. odoratissima*. The studies were continuing.

Studies on starch movement in rain DS Vs. winter DS teas (June 2000 - March 2001)

In an attempt to retude rain crop and enhance the early crop several estates in Darjeeling resorted to DS during rain (July-August). A study, therefore, was conducted to investigate the impact of rain DS on bush health as compared to conventional winter DS. Starch contents in roots was monitored from June 2000 onward at monthly intervals for both the treatments (rain and winter deep skiff). An additional treatment in the form of foliar spraying of MOP (2 to 3 rounds) before skiffing was also tried to study the influence of foliar spraying of potash on starch build-up. Investigations were carried out in four sites under three different elevations and two cultivars (Assam and China). Details are given below :

Sites : North Tukvar T.E. (750 m) with China jat
North Tukvar T.E. (750 m) with Assam jat
Sungma T.E. (1650 m) with China jat
Sungma T.E. (1220 m) with China jat

Treatments :
1. Rain DS with foliar MOP
2. Rain DS without foliar MOP
3. Winter DS with foliar MOP

Replication : 5 bushes per treatment

The root starch content irrespective of elevation and cultivar difference was found to remain within 7.4% and 13.6% (10.40 ± 1.59) between June and August at all the sites. Thereafter, starch content showed gradual increase from September onwards reaching the peak in December and declined again. Between June and March root starch content was found to be lowest in the month of March which was probably

Table 12.12 Starch content (% w/w) in root and branch under rain and winter deep skiffing

Site/ Month	Root			Branch		
	Winter DS	Rain DS	Rain DS + MOP	Winter DS	Rain DS	Rain DS+ MOP
i) North Tukvar : China jat, 750 m elevation						
Pre skiffing						
Jun	12.16	13.45	13.63	5.47	5.76	5.95
Jul	10.00	10.63	8.67	12.20	10.57	10.63
Post skiffing						
Aug	10.36	9.69	6.84	10.15	10.70	11.48
Sep	10.86	10.65	9.53	12.36	11.23	11.38
Oct	12.32	12.31	12.68	8.57	8.67	8.53
Nov	12.93	15.63	15.67	6.47	6.19	6.18
Dec	19.05	19.95	19.86	4.77	4.34	4.60
Jan	19.18	19.75	19.36	10.19	9.88	10.31
Feb	8.87	9.05	9.22	15.82	16.88	16.21
Mar	5.65	6.31	6.56	8.08	8.39	8.30
ii) North Tukvar : Assam jat, 750 m elevation						
Pre skiffing						
Jun	-	-	-	-	-	-
Jul	9.40	7.39	8.60	6.38	8.02	8.22
Post skiffing						
Aug	9.76	9.39	9.64	9.34	7.67	9.28
Sep	9.59	9.19	9.19	7.85	8.06	8.80
Oct	15.11	13.86	13.35	9.19	8.68	9.13
Nov	15.24	14.34	14.83	8.79	9.63	9.17
Dec	20.11	21.05	21.21	5.32	6.05	5.88
Jan	17.42	17.65	17.48	9.80	10.20	10.02
Feb	12.39	8.96	9.22	14.77	15.35	15.79
Mar	5.37	6.73	7.18	7.85	8.01	8.23
iii) Sungma : China jat, 1650 m elevation						
Pre skiffing						
Jun	8.47	10.22	9.50	8.18	8.54	8.19
Jul	10.06	9.98	9.73	10.42	10.33	10.85
Post skiffing						
Aug	12.89	11.53	12.03	11.14	11.07	11.17
Sep	12.82	12.20	12.21	7.36	8.06	8.63
Oct	13.68	14.01	13.18	9.59	9.33	8.97
Nov	18.60	17.19	17.80	7.33	7.58	7.15
Dec	20.66	22.28	21.25	8.48	7.33	7.24
Jan	19.19	19.08	20.68	8.77	8.22	8.49
Feb	10.95	10.80	10.53	15.42	15.91	15.84
Mar	7.64	8.91	7.61	9.47	9.95	9.98

iv) Sungma : China jat, 1220 m elevation

Pre skiffing						
Jun	11.67	12.38	12.10	5.83	6.40	5.92
Jul	9.76	9.12	8.87	5.93	6.17	7.56
Post skiffing						
Aug	11.84	9.29	10.66	10.91	11.53	10.65
Sep	12.26	8.30	10.74	5.40	6.41	6.32
Oct	15.11	14.89	14.66	8.52	8.49	8.52
Nov	16.35	15.29	15.64	7.41	7.84	7.71
Dec	21.35	21.74	22.25	3.69	4.53	4.17
Jan	18.67	18.85	19.92	8.63	8.93	9.24
Feb	9.49	9.17	9.09	15.29	15.75	15.82
Mar	5.57	8.52	9.27	7.53	8.50	8.07

due to use of the reserve energy for fresh growth in early spring.

Deep skiffing in the rains (after mid-July) suppressed root starch content by around 10% in the post recovery (August/September) period. Low elevation chinary teas showed higher decline (17%) in root starch content following skiffing, compared to low elevation Assam or high elevation China teas (3.4% to 6.7%). Pre skiffing foliar spraying of MOP apparently did not influence root starch build-up. The study indicates that in view of low starch content in the roots, rain deep skiffing as a regular practice may be injurious to bush health.

Stem starch content showed a higher level during July and August compared to June and declined between September and December. Highest stem starch content was recorded in the month of January. Foliar spraying of MOP failed to show any effect on stem starch.

Clonal Screening Trial

In continuation of earlier report (Ann. Sci. Rep., 2001-02), 31 different cultivars representing both TV and garden series clones as well as few seed stocks were planted out in field. Plot size was 75 cm x 1080 cm; with 288 plants of each variety and the spacing was 105 cm x 60 cm with single hedge planting. Plants established well. The list of the planted materials are given below.

List of the planted varieties

TV23, TV25, SNT8, SNT10, MOR33, TJ34, TV26, TS491, TS520, HB19, BJ19, HP30, KG5, TV17, HP12, TV29, KOL26, DP41, DP10, TV9, DP36, BJ5, Teen Ali 17, TV22, S3A3, T78, TV28, TV1, TV2, TV16 and TV20.

APPENDIX A

LIST OF EXPERIMENTS CONDUCTED IN MEMBER ESTATES

Sl. No.	Experiments	Site	Index No.	Year of starting
Upper Assam				
1.	Long term agricultural trial	Nudwa T.E.	AS 237	1991
2.	NPK trial on mature tea	Hazelbank T.E.	AS 214A	1991
3.	NPK trial on mature tea	Nudwa T.E.	AS 213A	1990
4.	NPK single element Vs control	Nudwa T.E.	AS 213B	1991
5.	NPK single element Vs control	Hazelbank T.E.	AS 214B	1991
6.	Trial on soil and foliar application of nutrient	Mokalbari T.E.	AS 276	2000
7.	Foliar application of nutrients	Mokalbari T.E.	AS 277	2000
8.	Trial on different methods of bringing-up of young tea (autumn planted)	Dikom T.E.	AS 273	1998
9.	Trial on different methods of bringing-up of young tea (spring planted)	Dikom T.E	AS 274	2000
10.	Trial with different spacing	Kamakhyabari T.E.	AS 275	1999
North Bank				
1.	Biclonal stock trial	H.Q., Thakurbari	AN 172	1979
2.	Long term agricultural trial to study yield and other characteristics	H.Q., Thakurbari	AN 179	1980
3.	Biclonal stock trial	H.Q., Thakurbari	AN 187	1981
4.	NPK manuring on mature tea - Set I	Phulbari T.E.	AN 220	1991
5.	Single dose NPK manuring - Set II	Phulbari T.E.	AN 220	1991
6.	Biclonal stock trial	H.Q., Thakurbari	AN 243	1991
7.	Biclonal stock trial	H.Q., Thakurbari	AN 244	1991
8.	Foliar application of boron to study the effect on yield	Dhendai T.E.	AN 264	1996
9.	Spacing trial to find out optimum spacing for growth and yield of tea	Kolony T.E.	AN 272	1998
10.	Trial on different methods of bringing-up of young tea (spring planted)	Texpore & Gogra T.E.	AN 270	1998

Cachar

1.	Trial on different methods of bringing-up of young tea (spring planted)	Rosekandy T.E.	C 76	1998
2.	Trial on different methods of bringing-up of young tea (autumn planted)	Rosekandy T.E.	C 77	1998
3.	Spacing trial	Rosekandy T.E.	C 78	1998

South Bank

No experiment was conducted during the period

Darjeeling

1.	Bringing up of young tea (autumn planted)	North Tukvar T.E.	Dj 72	1998
2.	Bringing up of young tea (spring planted)	Sungma T.E.	Dj 73	1998
3.	Trial to find out ideal time and dose of manuring in Darjeeling	Sungma T.E.	Dj 74	1999
4.	Trial on performance of Darjeeling clones	Sungma T.E.	Dj 75	1999
5.	Effect of different plucking rounds in clones and seed jat	Phoobsering T.E.	Dj 76	1999
6.	Organic Vs inorganic manures	Sungma T.E.	Dj 77	1999
7.	Trial with Pronto and Perfectose (Discontinued from the season ending 2002)	Bannockburn T.E.	Dj 78	2000

Terai

1.	Bringing-up of young tea (spring planted)	Pahargoomiah T.E.	D 131	1998
2.	Bringing-up of young tea (autumn planted)	Pahargoomiah T.E.	D 132	1998
3.	Trial on different spacing	Mohurgong/Gulma T.E.	D 133	1998
4.	Trial on organic Vs inorganic nitrogen	Kiranchandra T.E.	D 134	1998

APPENDIX B

PAPER PUBLISHED/PRESENTED

Aradhana Barooah, AK. Barooah, R. N.Singh Yadav and R. Thakur (2003). A study on heavy metals in tea ecosystems. *Abstracts of papers*, 48th Ann. Tech. Session, Assam Science Society (2003), held at Assam University, Silchar, p.17. .

M. Hazarika and A K. Barooah (2003). Global perspectives of tea quality. Paper presented in International Tea Convention 2003 held at Kolkata, March 5-8, 2003.

A Buragohain (2002) Phenotypic and genotypic evaluation of tea germplasm and their use in molecular breeding of tea *(Camellia sinensis* L). Paper presented in the International Symposium on Plant Biodiversity : Conservation and Evaluation, held at Bose Institute, Kolkata during December 17 -20.

T. S. Barman (2002). Role of auxin on growth of tea. Paper presented at the Plantation Crop Symposium (PLACROSYM - XV), held at Mysore during December 10-13.

B. Bera (2002). Randomly Amplified Polymorphic DNA (RAPD) marker analysis in tea *(Camellia sinensis* L.) generative clones. Paper presented at the Plantation Crop Symposium (PLACROSYM XV), held at Mysore, during December 10-13.

P. K. Bordoloi (2003). An econometric study on differential in production, export and domestic consumption of tea. Paper presented at the National Seminar on 'Recent Developments in Statistical

Methods and Operation Research, organised by Department of Statistics, Dibrugarh University, on March 20.

M. Goswami (2003). Studies of the nature of bud break and shoot regeneration in cultivated varieties of tea *(Camellia sinensis* (L.) O. Kuntze) under different tipping measures. Paper presented at 2nd International Congress of Plant Physiology, New Delhi, January 8-12.

Shyamal Prasad Baruah (2003). Effect of shade on shoot growth pattern and its relation to yield. Poster paper presented at 2nd International Congress of Plant Physiology, New Delhi, January 8-12

Kamruza Zaman Ahmed (2003). Study of the genetic variation in morphological and physiological characters of cultivated tea plant. Poster paper presented at 2nd International Congress of Plant Physiology, New Delhi, January 8-12.

B. K. Barthakur, S. R. Sarmah, P.K. Dutta and Karan Singh (2003). Effect *of* microbial bioagents in controlling certain pests and diseases of tea. Paper presented in the 5th National Symposium on Current Trends in Research on Microorganisms held in the Department of Botany, University of Calcutta, on February 23.

APPENDIX C

SUMMARY OF METEOROLOGICAL OBSERVATIONS 2002
STATION : SILCOORIE

LONGITUDE : 92°48' E LATITUDE : 24° 50' N ELEVATION : 39.6 m amsl

Months	Temperature °C				Rainfall mm		Days with rain with 0.3 mm & above	Sunshine Hours		Wind speed km/hr		Relative Humidity %		Soil temperature °C (BARE)					
														At 0619 hrs (IST)			At 1319 hrs (IST)		
	Mean Daily Max	Mean Daily Min	Normal Max	Normal Min	Total Monthly	Normal		Mean Daily	Normal	Mean Daily	Normal	a.m.	p.m.	5 cm	15 cm	30 cm	5 cm	15 cm	30cm
JAN	26.0	12.3	25.6	10.7	14.3	14.2	3	6.4	7.7	41.3	37.4	92	51	15.3	16.8	X	29.7	27.6	X
FEB	29.8	13.4	27.4	12.9	0.0	53.0	0	8.3	7.9	54.3	55.9	90	34	17.4	18.6	X	63.7	32.0	X
MAR	32.3	15.8	30.4	16.9	136.9	146.6	7	7.7	7.8	69.4	73.6	90	33	21.6	23.1	X	37.0	35.4	X
APR	X	X	31.5	20.6	220.9	295.5	11	6.1	7.4	83.8	81.2	X	X	23.2	24.3	X	34.2	33.0	X
MAY	X	X	31.7	22.7	412.9	401.4	20	5.3	6.5	83.1	72.5	X	X	24.9	26.0	X	34.3	32.8	X
JUN	X	X	32.0	24.5	296.3	554.6	26	3.4	4.8	55.9	62.7	X	X	27.1	28.2	X	33.8	32.7	X
JUL	X	X	32.1	24.9	386.2	501.9	29	2.5	4.3	52.4	60.6	X	X	27.5	28.5	X	34.2	33.1	X
AUG	X	X	32.5	24.9	376.3	418.2	20	4.5	5.0	65.7	54.7	X	X	28.2	29.3	X	35.7	34.5	X
SEPT	X	X	32.2	24.4	193.7	348.5	13	6.2	5.4	55.1	49.2	X	X	27.8	29.0	X	35.7	33.8	X
OCT	X	X	31.6	22.5	32.8	184.2	5	5.7	6.6	39.2	38.2	X	X	26.4	27.8	X	34.6	33.0	X
NOV	X	X	29.8	17.7	54.9	34.2	5	6.7	7.8	41.1	63.7	X	X	21.5	23.0	X	31.5	30.0	X
DEC	x	X	27.1	12.6	13.5	13.3	3	7.5	8.0	38.2	32.4	x	x	17.5	18.9	x	27.8	26.3	x

X - Data not available

SUMMARY OF METEOROLOGICAL OBSERVATIONS 2002

STATION : TOCKLAI

LONGITUDE : 94° 12' E LATITUDE : 26° 47' N ELEVATION : 96.5 m amsl

Months	Temperature °C				Rainfall mm		Days with rain with 0.3 mm & above	Sunshine Hours		Wind speed Km/hr.		Relative Humidity%		Soil temperature °C (Bare)					
														At 0613 hrs (IST)			At 1313 hrs (IST)		
	Mean Daily Max	Mean Daily Min	Normal Max	Normal Min	Total Monthly	Normal		Mean Daily	Normal	Mean Daily	Normal	a.m.	p.m.	5 cm	15cm	30 cm	5 cm	15 cm	30 cm
JAN	21.8	10.9	22.3	9.5	21.7	21.0	8	5.0	6.0	8.7	19.5	97	60	13.8	16.3	18.2	23.4	19.8	18.4
FEB	26.1	10.7	24.0	12.1	12.6	35.0	5	7.2	6.2	15.8	33.2	94	49	16.0	18.9	20.7	29.0	23.8	20 9
MAR	27.7	16.8	27.3	15.7	53.1	74.9	11	6.5	6.5	23.8	47.3	92	50	19.3	22.0	23.4	31.1	26.6	23.7
APR	28.5	20.2	28.5	19.2	132.8	191.0	18	5.1	5.9	27.8	52.9	92	61	22.2	24.2	25.4	31.7	28.9	25.6
MAY	30.2	22.8	29.9	22.1	231.8	270.2	16	6.1	5.2	21.4	47.0	92	64	24.7	26.5	27.5	33.8	30.5	27.9
JUN	31.9	25.4	31.6	24.4	190.1	316.8	19	4.6	4.6	29.3	49.6	91	71	27.4	28.7	29.5	34.4	32.0	29.9
JUL	31.5	25.9	32.1	24.8	381.9	386.3	25	3.1	4.7	24.3	54.1	94	77	27.9	29.2	30.0	34.2	31.9	30.2
AUG	31.6	25.6	32.1	24.9	395.8	332.4	23	4.8	5.1	19.8	45.5	94	74	27.2	28.9	29.8	34.4	31.9	30.1
SEPT	32.0	24.8	31.2	24.1	112.5	255.7	15	5.9	5.0	20.0	36.5	92	68	26.9	28.7	29.9	36.3	32.8	30.3
OCT	29.1	21.2	29.4	21.1	67.9	118.4	7	6.6	5.7	8.9	26.1	96	65	23.9	26.0	27.5	33.5	30.1	28.0
NOV	26.5	16.8	26.5	15.5	42.4	25.5	5	6.3	6.3	8.2	18.5	96	63	19.2	21.8	23.7	28.5	25.6	24.0
DEC	23.1	12.5	23.4	10.7	28.3	12.3	7	5.8	6.2	6.8	16.7	97	64	15.4	17.9	20.1	25.1	21.8	20.2

SUMMARY OF METEOROLOGICAL OBSERVATIONS 2002

STATION : DIKOM

LONGITUDE : 95° 08' E LATITUDE : 27° 30' N ELEVATION : X

Months	Temperature °C				Rainfall mm		Days with rain with 0.3 mm & above	Sunshine hours		Wind speed km/ha		Relative Humidity%		Soil temperature °C (ARE)					
														At 0608 hrs (IST)			At 1308 hrs (IST)		
	Mean Daily Max	Mean Daily Min	Normal Max	Normal Min	Total Monthly	Normal		Mean Daily	Normal	Mean Daily	Normal	a.m.	p.m.	5 cm	15cm	30 cm	5 cm	15 cm	30 cm
JAN	22.8	10.4	22.9	9.2	59.7	34.4	9	x	x	14.2	14.7	95	58	x	x	x	x	x	x
FEB	26.2	13.0	23.9	12.4	24.5	60.0	5	x	x	19.0	28.3	94	51	x	x	x	x	x	X
MAR	26.9	16.4	26.2	15.5	85.7	135.7	11	x	x	28.4	34.5	92	53	x	x	x	x	x	X
APR	27.6	19.6	28.6	18.6	421.7	208.3	17.	x	x	30.8	48.6	93	66	x	X	x	x	x	x
MAY	30.4	22.2	29.8	21.5	238.5	348.1	14	x	x	28.0	39.0	90	65	x	x	x	x	x	X
JUN	32.1	24.9	31.5	24.0	425.2	416.7	23	x	x	32.8	34.3	93	72	x	x	x	x	x	X
JUL	31.4	24.9	31.6	24.8	471.3	466.7	27	x	x	24.6	32.8	96	81	x	x	x	x	x	X
AUG	30.9	25.2	31.7	24.6	399.0	411.5	19	x	x	22.5	41.5	93	73	x	x	x	x	x	X
SEPT	31.6	23.8	31.5	24.1	210.9	353.5	14	x	x	21.6	23.9	93	71	x	x	x	x	x	X
OCT	30.5	20.7	30.0	20.8	35.6	121.0	6	x	x	13.0	18.1	94	62	x	x	x	x	x	X
NOV	27.6	16.0	27.8	15.7	54.2	25.1	5	x	x	11.6	14.8	97	57	x	x	x	x	x	X
DEC	24.5	11.0	25.6	9.8	1.6	5.4	1	x	x	11.8	13.7	98	56	x	x	x	x	x	x

X - Data not available

SUMMARY OF METEOROLOGICAL OBSERVATIONS 2002

STATION: THAKURBARI

LONGITUDE: 92° 42' 35" E LATITUDE: 26° 48' 35" N ELEVATION: 92.45 m amsl

Months	Temperature °C				Rainfall mm		Days with rain with 0.3 mm & above	Sunshine Hrs.		Wind speed km/hr		Relative Humidity %		Soil temperature °C (BARE)					
														At 0619 hrs (IST)			At 1319 hrs (IST)		
	Mean Daily Max	Mean Daily Min	Normal Max	Normal Min	Total Monthly	Normal		Mean Daily	Normal	Mean Daily	Normal	a.m.	p.m.	5 cm	15 cm	30 cm	5 cm	15 cm	30 cm
JAN	24.6	9.0	23.9	8.7	6.8	15.8	3	6.5	7.2	9.4	23.8	94	50	13.6	17.4	x	28.8	21.7	X
FEB	28.5	10.9	25.6	11.5	6.4	23.7	1	7.7	7.0	20.7	42.0	91	40.	16.6	20.4	x	32.9	25.8	X
MAR	29.9	14.3	28.9	15.2	84.8	47.7	7	6.2	6.9	28.3	70.1	87	42	20.9	23.4	x	32.9	28.4	X
APR	29.6	17.5	29.7	18.7	275.5	141.6	15	5.0	6.5	32.2	78.5	92	57	22.0	23.7	x	31.4	27.9	x
MAY	31.3	20.4	31.0	21.3	277.9	252.5	14	5.9	5.9	18.4	52.2	88	62	24.8	26.3	x	33.9	29.3	X
JUN	31.9	22.0	31.9	23.9	311.5	428.5	21	3.9	4.7	19.0	49.4	93	75	27.2	28.3	x	33.4	31.1	X
JUL	31.6	22.9	32.1	24.5	585.2	424.2	27	2.6	4.3	14.6	44.7	95	76	26.7	28.6	x	33.0	30.8	X
AUG	32.4	21.8	32.5	24.5	313.5	314.2	19	4.5	4.9	12.8	35.2	94	72	27.3	28.7	x	33.5	30.8	X
SEPT	33.3	20.1	31.7	23.4	88.3	323.4	11	5.8	5.0	x	29.2	93	67	26.9	28.8	x	34.6	31.7	X
OCT	31.7	19.5	30.6	19.9	67.9	131.1	7	7.6	6.9	x	21.6	93	60	23.8	26.0	x	33.4	29.9	X
NOV	28.9	14.7	28.3	14.1	51.4	17.3	5	7.2	7.9	x	17.8	95	55	19.6	22.1	x	29.4	26.1	X
DEC	25.9	10.2	25.3	9.6	20.8	14.0	3	6.9	7.7	x	17.7	94	53	15.9	18.5	x	25.8	22.1	X

X - Data not available

SUMMARY OF METEOROLOGICAL OBSERVATIONS 2002

STATION : CHUAPARA

LONGITUDE : 89°28' E LATITUDE : 26° 44' N ELEVATION :190.8 m amsl

Months	Temperature °C				RAINFALL mm		Days with rain 0.3 mm & above	Sunshine Hours		Wind speed Km/hr		Relative Humidity %		Soil temperature °C (BARE)					
														At 0632 hrs (IST)			At 1332 hrs (IST)		
	Mean Daily Max	Mean Daily Min	Normal Max	Normal Min	Total Monthly	Normal		Mean Daily	Normal	Mean Daily	Normal	a.m.	p.m.	5 cm	10 cm	20 cm	5 cm	10 cm	20 cm
JAN	24.2	9.6	24.4	9.2	23.2	12.6	5	6.0	6.5	38.5	40.6	89	47	14.9	15.9	16.7	23.8	20.4	17.8
FEB	27.4	11.9	26.1	11.1	0.6	32.7	1	7.1	6.8	54.3	53.6	88	40	17.1	18.0	19.0	27.3	24.0	20.5
MAR	29.5	16.1	29.7	14.7	92.8	52.6	8	7.0	6.9	64.8	61.2	85	44	20.6	21.4	22.2	29.5	27.1	24.0
APR	29.1	19.2	31.4	18.7	291.6	167.3	21	5.6	6.7	63.1	57.3	84	60	23.4	24.1	24.8	29.0	27.6	26.0
MAY	31.4	21.9	31.9	21.7	97.7	397.4	14	6.6	6.2	59.4	46.5	82	62	26.3	27.1	27.5	31.4	30.1	28.7
JUN	31.3	24.1	32.1	23.9	727.3	846.7	22	3.7	4.0	50.7	37.9	89	72	27.1	27.8	28.1	31.2	30.0	30.0
JUL	29.8	24.8	31.9	24.5	X	1036.5	x	0.9	3.0	37.4	33.8	91	80	27.0	27.7	28.0	30.0	29.1	28.8
AUG	X	X	32.2	24.4	X	785.3	X	X	3.9	X	31.9	X	X	x	x	x	x	x	X
SEPT	30.5	22.8	31.8	23.4	X	597.2	x	3.6	4.2	28.6	28.5	90	71	27.0	27.9	28.2	30.5	29.7	28.9
OCT	31.2	19.5	31.6	20.1	125.2	154.9	8	7.6	7.2	29.3	29.9	89	56	25.2	26.1	26.8	32.0	29.5	27.9
NOV	29.2	15.0	29.5	14.5	1.0	10.6	1	7.9	7.7	27.5	31.5	89	50	21.0	22.1	22.9	28.9	25.9	23.8
DEC	25.9	11.8	26.3	10.7	39.0	8.6	5	6.8	7.1	28.0	34.8	91	51	17.7	18.7	19.6	25.4	22.3	20.3

X - Data not available

SUMMARY OF METEOROLOGICAL OBSERVATIONS 2002

STATION : GUNGARAM

LONGITUDE : 88°48' E LATITUDE : 26° 38' N ELEVATION : 123.6 m amsl

Months	Temperature °C				Rainfall mm		Days with rain with 0.3 mm & above	Sunshine Hours		Wind speed km/hr		Relative Humidity%		Soil temperature °C (BARE)					
														At 0635 hrs (IST)			At 1335hrs (IST)		
	Mean Daily Max	Mean Daily Min	Normal Max	Normal Min	Total Monthly	Normal		Mean Daily	Normal	Mean Daily	Normal	a.m.	p.m.	5 cm	15cm	30cm	5 cm	15 c m	30 cm
JAN	23.9	7.5	22.5	9.0	48.4	11.5	3	2.9	7.1	15.1	26.9	96	57	13.2	15.3	18.2	23.6	18.0	18.4
FEB	26.6	10.0	25.8	11.5	0.0	12.6	0	6.1	7.5	27.2	42.4	95	54	15.4	16.8	19.0	26.7	20.5	19.4
MAR	29.5	14.2	31.0	16.0	65.4	27.4	5	7.1	8.4	42.6	67.0	91	53	19.9	21.6	23.0	29.6	24.9	23.3
APR	30.3	18.4	32.5	20.7	144.7	75.7	12	6.0	8.3	52.8	69.2	93	62	22.7	24.3	25.2	30.8	27.2	25.6
MAY	32.1	21.3	32.9	22.5	293.6	247.6	13	6.7	8.0	31.6	52.7	95	68	25.3	27.1	28.2	32.9	29.9	28.7
JUN	31.7	23.4	32.5	24.0	374.3	601.1	19	3.9	6.9	28.6	42.0	97	79	25.9	27.0	29.0	32.3	30.9	29.5
JUL	29.3	23.2	31.6	24.4	1291.7	960.4	27	1.9	5.2	21.0	34.2	96	84	25.4	26.3	27.7	30.3	27.9	28.0
AUG	31.2	23.8	32.5	24.7	359.6	667.8	22	5.1	6.2	23.7	29.0	97	78	26.1	27.4	28.7	31.9	29.9	29.0
SEPT	31.8	23.0	31.9	23.8	312.5	517.8	18	4.4	6.1.	15.4	22.8	97	73	25.2	26.9	29.0	32.5	29.8	29.4
OCT	32.3	19.5	31.8	20.6	68.4	140.4	3	5.4	7.5	9.1	17.1	95	62	23.2	25.3	27.3	33.0	28.6	27.6
NOV	31.0	14.8	29.7	15.5	0.0	16.4	0	4.8	7.7	14.9	15.0	92	53	19.7	21.2	23.6	31.2	26.0	24.1
DEC	26.4	10.9	26.6	11.0	0.0	13.4	0	3.6	7.3	22.2	17.6	94	57	15.8	18.6	20.8	26.6	22.1	21.2

X - Data not available

SUMMARY OF METEOROLOGICAL OBSERVATIONS 2002

STATION : NAGRAKATA

LONGITUDE : 88° 55' E LATITUDE : 26°54' N ELEVATION : 228.6 m amsl

Months	Temperature °C				Rainfall mm		Days with rain with 0.3 mm & above	Sunshine hrs		Wind speed Km/hr		Relative Humidity %		Soil temperature °C (BARE)					
														At 0634 hrs (IST)			At 1334 hrs (IST)		
	Mean Daily Max	Mean Daily Min	Normal Max	Normal Min	Total Monthly	Normal		Mean Daily	Normal	Mean Daily	Normal	a.m.	p.m.	5 cm	10 cm	20 cm	5 cm	10 cm	20 cm
JAN	23.1	10.8	23.4	10.5	18.2	14.3	5	6.0	7.0	33.8	60.2	98	61	12.9	14.0	16.0	23.2	20.7	17.7
FEB	26.6	13.0	25.1	12.6	0.3	25.2	1	6.9	6.8	37.3	71.5	96	53	15.9	16.9	18.6	27.4	24.8	21.2
MAR	28.9	17.3	29.1	16.2	99.0	44.0	8	6.6	6.9	48.0	88.7	93	60	20.3	21.1	22.7	32.0	29.2	25.7
APR	28.4	19.4	30.8	19.7	212.6	135.0	16	5.2	6.8	44.4	96.6	95	73	22.0	22.6	23.6	30.6	28.3	26.2
MAY	30.6	22.3	30.7	21.8	260.8	362.2	15	6.0	6.3	38.6	84.3	92	67	25.5	26.1	26.8	34.2	31.4	29.4
JUN	30.9	24.5	30.8	23.9	451.9	798.2	24	3.1	4.1	28.5	68.6	96	77	26.8	27.2	27.8	33.3	31.1	29.6
JUL	29.3	24.9	30.5	24.2	1353.4	965.5	29	1.0	3.2	21.4	63.7	99	88	26.6	26.8	27.3	31.6	29.8	28.7
AUG	30.7	24.6	31.0	24.1	505.4	721.2	23	3.1	4.1	26.4	60.8	97	81	26.9	27.3	27.9	34.4	32.1	30.3
SEPT	31.1	23.5	30.6	23.1	406.0	566.6	16	4.4	4.7	24.9	53.9	96	77	26.2	26.8	27.6	33.8	31.6	29.9
OCT	30.3	20.1	30.1	19.9	134.6	201.3	10	7.7	7.6	21.1	52.1	96	67	23.2	23.9	25.0	33.0	30.3	28.2
NOV	28.2	15.8	27.7	15.2	7.6	23.0	2	8.0	8.2	21.7	54.2	93	62	18.5	19.2	20.9	28.7	26.5	23.8
DEC	24.6	13.1	24.9	11.7	55.2	8.5	4	6.1	7.8	22.9	54.1	96	63	15.6	16.5	17.9	25.5	22.7	20.6

SUMMARY OF METEOROLOGICAL OBSERVATIONS 2002

STATION : GING T.E.

LONGITUDE : 88°19' E LATITUDE : 27° 17' N ELEVATION : 1219.2 m ams

Months	Temperature °C				Rainfall mm			Sunshine Hrs.		Wind speed km/hr		Relative Humidity%		Soil temperature °C (BARE)					
														At 0635 hrs (IST)			At 1335 hrs (IST)		
	Mean Daily Max	Mean Daily Min	Normal Max	Normal Min	Total Monthly	Normal	Days with 0.3 mm & above	Mean Daily	Normal	Mean Daily	Normal	a.m.	p.m.	5 cm	10 cm	20 cm	5 cm	10 cm	20 cm
JAN	16.9	8.3	16.3	8.2	17.7	16.9	6	5.1	5.2	51.4	36.2	73	56	10.7	12.3	13.1	21.2	16.3	16.3
FEB	19.8	10.9	18.1	9.8	0.3	14.3	1	5.0	5.2	57.3	49.4	76	59	13.3	14.6	15.3	24.1	19.1	18.9
MAR	23.1	13.1	21.6	12.8	44.2	27.8	8	5.4	5.5	68.4	62.4	77	58	15.9	17.0	17.7	27.0	22.6	21.6
APR	23.5	15.0	24.9	15.7	82.0	99.7	5	5.4	6.0	66.7	64.9	74	72	18.1	18.8	19.3	27.5	23.2	22.8
MAY	24.9	17.2	25.9	18.0	77.7	117.3	14	5.1	5.3	60.7	50.1	95	69	22.4	21.5	23.6	33.2	27.9	25.7
JUN	26.2	20.0	26.2	19.6	202.3	395.6	23	2.1	3.1	41.0	40.8	92	83	22.7	22.8	22.9	29.0	25.7	25.4
JUL	25.9	20.4	25.9	20.3	609.1	478.1	29	1.6	2.6	27.8	32.9	96	89	23.1	23.2	23.6	28.7	25.6	28.3
AUG	26.2	19.6	26.1	19.8	432.1	496.7	24	4.1	3.0	42.7	32.2	95	82	23.1	23.4	23.8	31.0	26.7	26.3
SEPT	25.6	18.9	25.3	19.2	148.0	338.6	15	3.6	3.2	42.5	40.1	89	80	21.9	22.4	23.0	29.6	25.7	25.0
OCT	24.2	16.0	24.0	16.5	42.0	80.0	6	5.6	5.6	46.7	39.7	82	73	18.8	19.9	20.7	28.2	24.4	24.1
NOV	21.9	12.9	21.3	13.2	1.8	35.6	1	6.9	6.0	49.0	38.0	78	67	15.0	17.4	17.9	27.8	22.4	22.0
DEC	18.3	10.1	18.4	9.9	0.0	15.3	0	4.8	6.8	40.4	36.7	76	67	13.1	14.5	15.0	22.4	18.2	18.2

TOTAL MONTHLY EVAPORATION (mm) OF N.E. INDIA

YEAR – 2002

STATIONS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
TOCKLAI	34.5	57.8	80.5	75.7	91.4	92.8	79.3	79.2	88.0	60.9	47.5
THAKURBARI	40.9	66.1	95.8	87.3	98.0	84.9	77.5	76.6	88.5	76.6	57.6
CHUAPARA	49.9	72.6	106.6	95.9	115.8	78.9	41.5	x	64.8	88.1	64.7
NAGRAKATA	42.0	64.1	88.0	82.2	109.9	70.7	51.5	72.1	72.9	80.3	63.3
GUNGARAM	56.5	57.2	105.3	118.3	80.3	59.4	60.1	60.5	70.8	92.7	73.3
SILCOORIE	47.6	69.0	99.2	99.6	105.1	78.9	70.7	102.0	96.0	77.8	73.2
GING	54.1	63.8	90.5	86.1	101.1	57.8	53.1	81.2	76.0	81.8	75.6